THE UTILIZATION OF ABANDONED MINING POND AS RETENTION POND TO CATER STORMWATER RUNOFF

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CIVIL ENGINEERING
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by

Ainil Husna Binti Mohd Sharir

Dissertation submitted in partial fulfillment of
the requirement for the
Bachelor of Engineering (Hons)
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CERTIFICATION OF APPROVAL

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Approved by,

______________________.
(Mrs. Husna Binti Takaijudin)

UNIVERSITI TEKNOLOGI PETRONAS
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January 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in the project, that the original work is my own except as specified in the references and acknowledgments, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

(AINIL HUSNA BINTI MOHD SHARIR)

ABSTRACT

Most abandoned mining ponds are suitable as retention or detention ponds. The pond chosen in this study satisfies the characteristics to be used as retention or detention pond. Shown by it locality, capacity, inlet and outlet facilities for the catchments considered in the study. The design rainfall was obtained from MASMA manual IDF curves using Bagan Serai town design storm coefficients. Time-series rainfall data which was obtained from Jabatan Pengairan dan Saliran (JPS) is analyze to obtained new rainfall intensity. The design discharges for inflow and outflow from the pond was obtained by using manual and computer modeling methods. The result shows that the design rainfall intensity is more conservative than that observed data. The result from the two methods used for design discharge was compared and analyze. It was found that the abandoned mining pond volume is adequate to cater stormwater management. The volume of retention pond given by MIDUSS modeling is higher compare to the manual calculation. Abandoned mining pond has yet to be looked at positively, with proper planning and political will it has the potential to be developed into prime real estate in the future.

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ABBREVIATIONS AND NOMENCLATURES

ARI	-Average Recurrence Interval
DID	-Department of Irrigation
IDF	-Intensity Duration Frequency
LID	-Low Impact Development
MASMA	-Urban Stormwater Management Manual for Malaysia
SUDS	-Sustainable Urban Drainage System Management
WSUD	-Water Sensitive Urban Design
VDF	-Volume Duration Frequency

CHAPTER 1

INTRODUCTION

1.1 Background

Water is essential to human and other lifeforms. It plays important role in the world economy, as it functions as a solvent for a wide variety of chemical substances and facilitates industrial cooling and transportation. It is cycled, by the precipitation and which occurs immediately following rainfall or as result of snowmelt. When a rainfall event occurs, several things can happen to the precipitation. Some of the precipitation infiltrates into the soil surface, some is taken up by plants and some is evaporated into the atmosphere. Stromwater is the rest of the precipitation that runs off land surfaces and impervious areas.

Stormwater discharges are generated by precipitation and runoff from land, pavements, building rooftops and other surfaces. These hardened surfaces are called 'impervious surfaces' and they do not allow rainfall to infiltrate into the soil surface like natural vegetation, so more of the rainfall becomes stormwater runoff. Storm water runoff accumulates pollutants such as oil and grease, chemicals, nutrients, metals, and bacteria as it travels across land. Heavy precipitation or snowmelt can also cause sewer overflows that may contaminate water sources with untreated human and industrial waste, toxic materials, and other debris.

Stormwater runoff can have a number of impacts. As development and imperviousness increase in an area, the natural capacity of the soil and vegetation to infiltrate and take up rainfall decreases, and more rainfall becomes stormwater runoff. This can produce negative impacts by causing erosion of land areas and stream banks, by causing or increasing flooding and also by carrying pollutants to surface waters. However, the impact almost all have been rectify by the well planning of the planner of the certain country. The idea of the project comes as to develop the analysis of stormwater.

Tin mining the major activities happen in Malaysia since 1820. The mining started after the arrival of hardworking Chinese immigrant mostly Cantonese and Hakka which was the manpower of the activities. Tin mining activities mainly occur at Peninsular on the western side of Malaysia. The alluvial deposited soil mainly the type of soil where the tin is found. The State of Perak is the oldest mining pond site. Taiping is the first town that the tin is being commercialized and by 1883, Malaysia had become the largest tin producer in the world. Continuously, by the end of 19th century, it was supplying about 55% of the world's tin compared with the 1992 about 30%.

After sometimes in 1990's, many of the ponds are already stopped operation and been abandoned for a long time. Although, government have include the act of ex-mining pond which stated that the rehabilitation of ex-mining pond will be use for certain planning unfortunately the real planning is still not clear. Narrowing down to the Perak state itself the Tin mining pond has been an abandoned pond that mainly being a wasted area. For ex- mining pond despite the use of mining pond as detention pond the utilization of mining pond can be an asset to Malaysia economy.

By referring to the practices given in the Urban Stormwater Management Manual for Malaysia (MASMA) this mining pond can be considered as the community even for the regional catchment. MASMA prove to be an effective system in order to maintain the environment quality standards for the next generation and beyond. It is also the practice and a set of guidelines for new development in Malaysia which uses natural process solutions to deal with storm water treatment. These techniques use engineering applications i.e. hydraulic structures to receive the surface water runoff.

1.2 Problem Statement

As Malaysia grows, development increases. When more houses, roads and businesses are constructed, water has nowhere to go and can cause serious drainage, pollutant, and sanitation problems. Focusing of impact to the hydrology cases, with the increasing of surface runoff because of imperviousness can cause huge problems to the country. In addition, surface runoff eventually will also carry pollution and spread to downstream area as they go along. Flash flood could happen anywhere if there is lack of well-planning of the government. Flash floods have occurred in most of the city and mostly in urban city like Kuala Lumpur and Johor. The development of the city may cause of the increase of imperviousness and the runoff.

The Department of Irrigation (DID) has taken pro-active step to introduce the integration of the storage facilities such as detention pond in the drainage network system. The detention pond are significant to stores the volume of water from new urban development area within certain time before it will be discharged to the nearest existing main stream. There are many options to tackle the stormwater problems. The aim for this project is to use the ex-mining pond as one of the case study. The relation is mining pond in Malaysia exist about many year ago and being abandoned because of lack of planning. The new solution is to make this abandoned pond to become as the stormwater will be decided in this project.

1.3 Objective

The followings are the main objective of the project:

1. To compute the design rainfall intensity from rainfall data collected from JPS.
2. To investigate the feasibility of the abandoned mining pond as retention pond solution for stormwater management.

1.4 Significant of Thesis

Towards Malaysia 2020, solving environmental issues is vital for Malaysia in order to achieve a fully developed nation status. Jabatan Pengairan dan Saliran (JPS) has taken the initiative to produce a world class manual called Urban Storm Water Manual for Malaysia (MASMA). It is a comprehensive manual use as a guideline for proposed development in Malaysia pertaining to storm water management.

The thesis adopted the procedures laid down by the manual. Once of the design rainfall derived from the raw rainfall data JPS obtained, computation for the storm water discharges was done by using manual and computer aided methods. Consequently examining the suitability of the ex mining pond chosen as retention pond for the catchments area.

The project is significant for author to learn how to compute design rainfall from raw data, design of drainage conveyance and design of retention pond of which knowledge is required for design engineer to submit layout plan, earthwork plan, road and drainage plan to local authorities for approval.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview of Hydrology Cycle

For this project the first hand theory is come from understanding of the hydrology. Hydrology means study of the occurrence, distribution, and motion of water on, in, and over the surface of the earth (DID2000). It deals with various forms of moisture that occur during the transformations that take place between liquid, solid and gaseous states of water in the atmosphere and on the surface layers of land masses. From an engineering perspective, hydrology is the application of science to the study of water resources, water supply and flooding.

Water supplies are typically taken from ground-water stores, from rivers, and from reservoirs or lakes. These water supplies generate the living of human creature. Then, the process begin as verse in Quran, "He (God) will sends the wind which moves the clouds ad spreads about the sky however He wills. He forms them into dark clumps and the rain come pouring down from the middle of the dark clumps. Whenever He will, His slaves will rejoice" (The Quran 30:48).

From the verse and science description we know that various processes come from the hydrological cycle. This cycle controls the distribution and movement of water in, on and above the earth's surface. The physical processes in the hydrological cycle consists of precipitation in the form of rain, haze, sleet and snow, and include surface runoff, evaporation, transpiration, infiltration, groundwater, ocean and lakes as in Figure 2.1. The precipitation is the driving force of providing water. Then, the surface runoff or overflow land is taking into consideration.

Surface runoff is the main factor that contribute of consideration quantitatively and qualitatively system for water management. This urban management will avoid the increasing of the volume and rates and better quality of surface runoff in the future. For infiltration, evaporation and transpiration the process help to reduce surface runoff. Infiltration become vice versa from surface runoff whereby decreasing of infiltration will result in increasing of surface runoff (DID2000).

Other than that, for the analysis and design the transpiration, infiltration and evaporation processes will be consider as a deduction factor for storage value. This consideration is important to avoid the overdesign of the hydraulic structures. All in all, the hydrology cycle is important to be known as we can investigate the control sources of water and hydrology is actually the first theory to know and will be use for hydraulics design afterwards.

Figure 2.1: The hydrological cycle

2.2 Overview of Stormwater Management

In past century the stormwater drainage system often route runoff to stream and river directly. Therefore, the water is not treated, which may have contain polluted substance which resulting in degradation of ecosystem structure and function (Allison et. al. 2008). For that instance, Framework Directive (Council Of European Communities, 2000) have been force to reach good status for clear water before 2015 (Miklas 2006). Therefore, Sustainable Urban Drainage System Management (SUDS) is introduced. SUDS implemented by the rising country such as UK and Europe for the beginning. Below is the development diagram of management of stormwater:

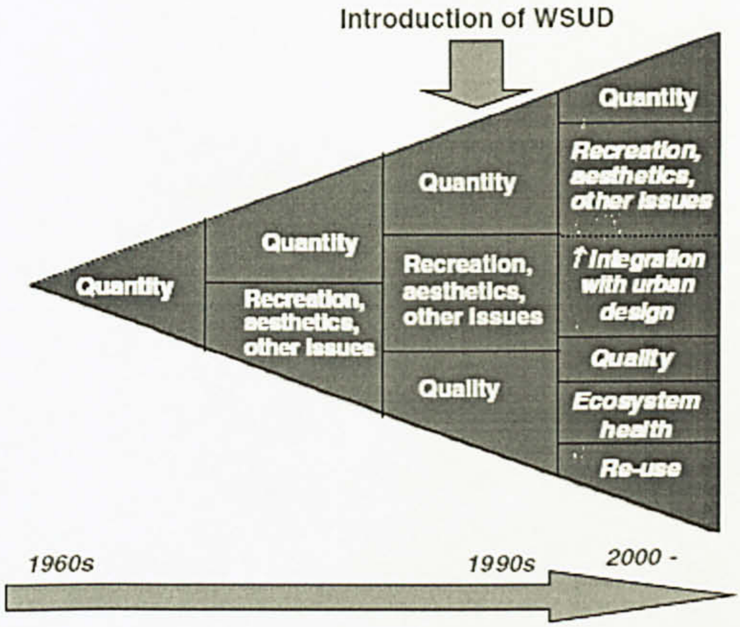

Figure 2.2: The development of stormwater management according to time.

There are decentralized stormwater management tools such as Low Impact Development (LID) or Water Sensitive Urban Design (WSUD) offers a sustainable solution to stormwater management which implemented in watershed scale (Allison et. al. 2008) . Moreover the tools designed to encourage the evaporation, evapotraspiration, groundwater recharge, reuse of water, pond usage, infiltration and harvest water at the source.

From the case study in Glasgow the objective of SUDS implementation is been determine. First of all, the suitability of the characteristic of a site is identified for the implementation of SUDS, then, the specifics SUD area is identified. SUDS Option Decision Support Key is identified to classify the quantity and quality potential of SUDS site for different SUDS technologies (Miklas 2006). Technologies have always known as the method and the engineering as the medium to make the work done.

The urban stormwater management consists of planning, design, construction, and operation functions. The planning part is the most crucial part of the procedure (DID2000). Planning for individual urban developments has been based on manv criteria. This has resulted in problems ranging from increased risk of flood elsewhere in the catchment and adverse water quality associated with receiving waters to a reduction (DID2000).

Municipal planning is undertaken to establish the form and extent of urban land use within a catchment and to meet the constraints of sustainable flows and constituent loads specified in the catchment management plan. The metropolitan area (or the urban part of the municipality) is one of the significant land uses within the catchment. Whether a plan covers a municipality or the whole of the metropolitan area depends mainly on the responsibilities for stormwater management within each State and Territory (DID2000).

In Malaysia MASMA (DID2000) objectively introduce stormwater management is to utilize the components of the urban drainage network and incorporate storage and treatment facilities on-site in order to improve the water quality before entering the receiving watercourse and to optimize relief from flooding problems. However, there are seven areas that have been found as impediment to sustainable stormwater management which are:

1. The problem in performance and cost
2. Lack of engineering standard and guidelines
3. Lack of responsibilities

4. No institutional responsibilities
5. No legislative mandate
6. Insufficient funding
7. The refrain to change

For the construction and operation function the power of authority is much anticipated as the importance of stromwater management cannot be taken forgranted. The quality and quantity of the stormwater is important for future living.

2.3 Description of Urban Drainage and Storage System Design Method

Since the environmental issues have been the highlighted the conventional methods of storage system is strictly is going to change to the sustainable urban drainage method. It is because of the water been discharged directly into the nearest receiving watercourse such as streams, rivers or lakes and may polluted the source of water. The conventional method also has separated the quantity with quality and lack of amenity of the procedures (DID2000). Moreover, flooding problems occurs because of inefficient of storage due to the high amount of water entering the river.

Land development decreases the natural storage of a watershed. The removal of trees and vegetation reduces the volume of interception storage (Subramanya 2007). In addition, no treatment facilities are incorporated into a conventional drainage system. The installation of a silt trap does not reduce the water pollution problem due to poor maintenance and it also blocks the flow of water due to the high amount of rubbish and silt that collects.

To balance the quantity, quality and amenity the new storage and treatment facilities are utilized. Many methods are introduced in the drainage design to cater for the flow from a new development before it enters the receiving watercourse. These facilities are installed at the downstream of the catchment area. Stormwater Management policies have been applied in order to mitigate the harmful effects of land development. The peak flow rate from post-development areas has been controlled by storage facilities to prevent disturbing the nearest existing conveyance system. Additionally, it also considers the condition of the catchment area before development in terms of the land characteristics, the natural flow before development and the rainfall characteristics. There are three main purposes of storage as listed below:

1. To store surface water runoff before entering to the river
2. To treat the water by infiltration, settlement and filtering
3. To minimize the flow rate of surface runoff from the contributing area

Stormwater quantity control facilities can be categorized in terms of its function as either detention or retention facilities (DID2000). Detention pond practices are often installed in urban stormwater drainage system in order to control the maximum outflow rate. It functions as storage and releases the flow gradually through the outlet control structure. In analysis and design of storage facilities, storage routing plays an important role to determine water surface elevation, outflow and volume of storage. Storage routing is quite similar to channel routing. If the system is a pond, the particular specific term 'pond routing' is applied. Pond routing is a mathematical procedure that models the response of a detention pond to a given storm event.

There are various methods have used to illustrate standard pond routing techniques. There are method name as Modified PUL'S Method, Goodrich Method and Order Runge-Kutta Method (SRK) (Subramanya 2007). The routing methods such as storage indication, Modified Puls Method accordingly to the basic relationship for the continuity equation as given in (Equation 2.1):

$$\Delta S = \Delta t\,(I - O)$$

where:

ΔS = Change of storage (m^3)

Δt = Routing time step (sec.)

I = Inflow discharge (m^3/sec)

O = Outflow discharge (m^3/sec)

2.4 Description of Rainfall Analysis and Surface Runoff

Starting from precipitation, the rainfall activities will given us the characteristic that varies and need to be calibrated. The rainfall data series is important for us to predict and get the peak and cumulative value of the rainfall during each time specifically. The time recurrence gives us the quantity of water discharge prediction in each average recurrence interval (ARI) or return period (DID2000).

There are three basic systems for providing precipitation measurements for use in real-time flood forecasting. Conventional ground based telemetric rain gauges, weather radar system, which is of growing importance in recent decades, and the third potentially useful measurement system is based upon the analysis of clouds shown by geo-stationary satellite images (Dugdale).

The rainfall data contain three variables which are frequency, duration and either depth or mean intensity (Nidal). Intensity-Duration-Frequency is the outcomes that can be conclude from the analysis of the rainfall. Using rational formula, the rainfall intensity represents the average rainfall over duration equal to the time of concentration for the catchment. Adam and Howard (1986) described two main characteristics that contribute to the design and analysis of urban drainage system. Initially, a rainfall event plays an important role in order to generate a runoff hydrograph.

A rainfall event has many characteristics such as its total volume, average intensity and total duration. Correspondingly, the runoff hydrograph consists of total volume and total duration of direct runoff. The combination of rainfall characteristics such as intensity-duration and volume-duration-frequency (VDF) may be described as unique frequencies. IDF curves are one of the combinations that are widely used as the input to many hydrologic design methods.

A new computer program called (RaDeR ver1.0) (Waleed 2009) was developed in this study as shown in. RaDeR estimate radar-derived rainfall using meteorological raw radar data. It is similar to 3D-Rapic Program, but it can create a 24 hours radar-derived rainfall report with 10 minutes duration according to Waleed ARM MSM Amin, G Abdul Halim, ARM Shariff and W Aimrun 2009 (Waleed 2009).

Rain gauges do not represent the areal rainfall at the watershed scale because they are merely point samples. In contrast, catchment area is sensitive to the spatial distribution of rainfall. The use of rain gauge data necessitates spatial interpolation of the rainfall data. The accuracy of the resultant rainfall is limited by the correlation structure of rainfall and the network density a radar-derived rainfall calibration model was successfully developed. The model gives better correlation when adjusted radar values are used instead of the original radar rainfall values.

The virtual rainfall stations created throughout the river basin produce a more representative rainfall distribution. It is believed that watershed river flow can be better estimated by using radar derived rainfall data. The methodology developed in this study will be further tested for its usefulness in helping policy and decision makers to have better tools in planning development projects in the river basin.

For meteorological data, an innovation to point rain estimation, named GMS-Rain, which estimates convective rainfall using information from the Geostationary Meteorological Satellite-5 (GMS-5) infrared (IR) images and numerical weather prediction (NWP) products in an Artificial Neural Network model were introduced. Although the estimates are indirect, meteorological satellites with fine temporal and spatial resolution cover broader areas that may be inaccessible or that may cause difficulties with the traditional rainfall measurement such as the deep forests, large water bodies or rigid mountains, therefore should be taken as complementary to rain gauge or radar measurements (Wardah 2009).

Runoff basically is the flowing of precipitation through a surface channel in a specific catchment. In addition, when the water when through the hydraulic structure such as the open-drain it is called the surface runoff. Runoff also can be called as overland flow because of the length and depth are small and the flow is in the laminar regime (Subramanya 2007). Surface runoff can be analysis by using Rational Method and Hydrograph method. MASMA stated that the rational method relates peak runoff to rainfall intensity through proportionality factor whereas hydrograph approach by considering for rainfall losses and temporary storage effects in transit (DID2000). The relation between rainfall and runoff very much depend on the catchment and climate.

2.5 Description of Integration of Ex-Mining Pond as Retention Pond

Referring to Ang et al,1998 , the tin mining activities in Peninsular Malaysia since the 1930's, has resulted in ex-mining land covering approximately 113,700 ha. Large tracts of these degraded former lowland dipterocarp forests remain idle till this day. Only about 9.7% of the ex-mining land has been converted into housing estates, fruit orchards, vegetable farms, recreational parks, and golf courses. Ex-mining land consists of sand and slime tailings. The sand is infertile and the area has harsh microclimate, whereas slime is more fertile but is normally water-logged (Ang & Ho 2002).

The ex-mining pond in Malaysia Large tracts of tin tailings remains unproductive. (Chan 1990) showed that only 4,730 ha (4.2%) of the ex-mining land had been utilised for agriculture and 5.5 % for other uses. The excessive uptake of heavy metals in the agricultural produce cultivated on tin tailings has rendered the site unsuitable for food crop production. Some of the heavy metals namely cadmium, mercury, arsenic and lead found in the fruits and vegetables produced from the ex-mining land have exceeded the permissible limits for human consumption.

The utilization of abandoned mining pond is predicted to be the best of detention facilities of it natural cause. Therefore the consideration of integration of ex-mining pond as a detention pond is cost effective. The analysis of the mining pond, consider for quantity and quality of the design. For quantity the storm event of 10-year ARI (minor) and 50-year ARI (major) is used for the pond design (Chang et. al. 2008).

For quality purposes, Ph, Dissolved Oxigen (DO), Suspended Solid (SS), Ammoniacal Nitrogen (NH_3-N), including 23 parameter of water quality have been analyse from ex-mining pond at Daerah Kinta, Ipoh and the result show that the Water Quality Index is of class IIB or Standard B based on EQA. This standard is suitable for domestic used (Ang et. al. 2008).

J. Liebens say that the pond and swales contain more concentration of heavy metals because of the longer accumulation of times compared street sweepings. The metal that have been determined by J. Liebens are Aluminium, Arsenic, Barium, Beryllium, Cadmium, Chromium, Copper, Lead, Mercury, Nickel, Silver and Zinc (Lieben 2001).

(Mahmud 2004) has done a very comprehensive research of water quality in about 12 tin mining ponds. The parameter that being investigate are hardness, acidity, alkalinity, biochemical oxygen demand, diluted oxygen, chemical oxygen demand and some significant heavy metals. Average value of hardness is about 64.00 ± 16.62 mg L_{-1} $CaCO_3$ which still in the rage that allowed Jabatan Alam Sekitar, 1986. For alkalinity is about 1.71 ± 0.45 mg L_{-1} $CaCO_3$, acidity about 0.26 ± 0.12 mg L_{-1} $CaCO_3$ still in allowable range but the BOD is high which average about 9.95 ± 3.64 mg L_{-1}. The investigation is taken place at abandoned mining pong around Selangor.

2.6 Development of Computer Aid and Modeling for Analysis and Design

Calculation of rainfall analysis and design sometimes comes in repeating mode. The best idea is to use some computer aid such as software that has been available in the market. It is realized that the software nowadays the civil engineer have been put effort to learn the software that available in the market to save a lot of time rather than doing manual calculation. However, the civil engineer need to plan and know the basic knowledge of hydrology and hydraulic in order to perform in those softwares (DID2000).

The development of software are now are not only focusing in the quantity method. There are also software nowadays include the quality aspect as well (DID2000). The basic principle that have required for the software is written in MASMA. There are:

1. Site-specific information which may range from simple data such as rainfall or drainage system data to detail parameter relatively.

2. Simpler method has to be used to provide a control strategy. The complex model has more risk than the simpler method.

3. The quality stimulation is not necessary even the quality problem have been considered as the mere important consideration depends on the hydrology and hydraulic process.

Jabatan Pengairan dan Saliran have been used MIDUSS for the design and checking of design. MIDUSS contained toolkit that have hydrologic models and hydraulic design methodologies into one. Below a diagram that shows differences of MIDUSS and other software that exist in Malaysia (Lariyah et. al.).

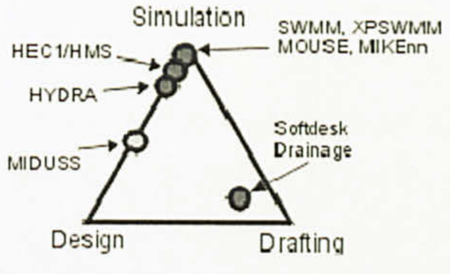

Figure 2.3: The position of MIDUSS compare to other software

CHAPTER 3

METHODOLOGY

3.1 Overall view

First of all, the author mainly involved in reviewing literature from previous research related to her project. Literature reviews is done on the concept of the rainfall studies, mining pond review and also quantity and some quality of mining pond. This literature reviews will help to understand in more details in the project scope and the available data that can being cooperate in author's project. Next, the consultation is made for the data input and better understanding of land use of the case study area. The consultation is mainly involved the developer, consultant and authority. After the data and understanding of the land use of have been achieved the core investigation will be precede.

This thesis is base on the analysis and design scope of work. The overall methodology is a quantitatively investigation on the source of water which is the rainfall intensity of the study area. After that the work continues until the design of the drainage path and the retention pond. In addition, some definition and scope of work for quality study of the retention pond will be include for future recommendation. Some computer technical aid is use for the project. Finally, result and discussion plus future recommendation will be include at the later part. The simplified methodology of this project as shown in Figure 3.1.

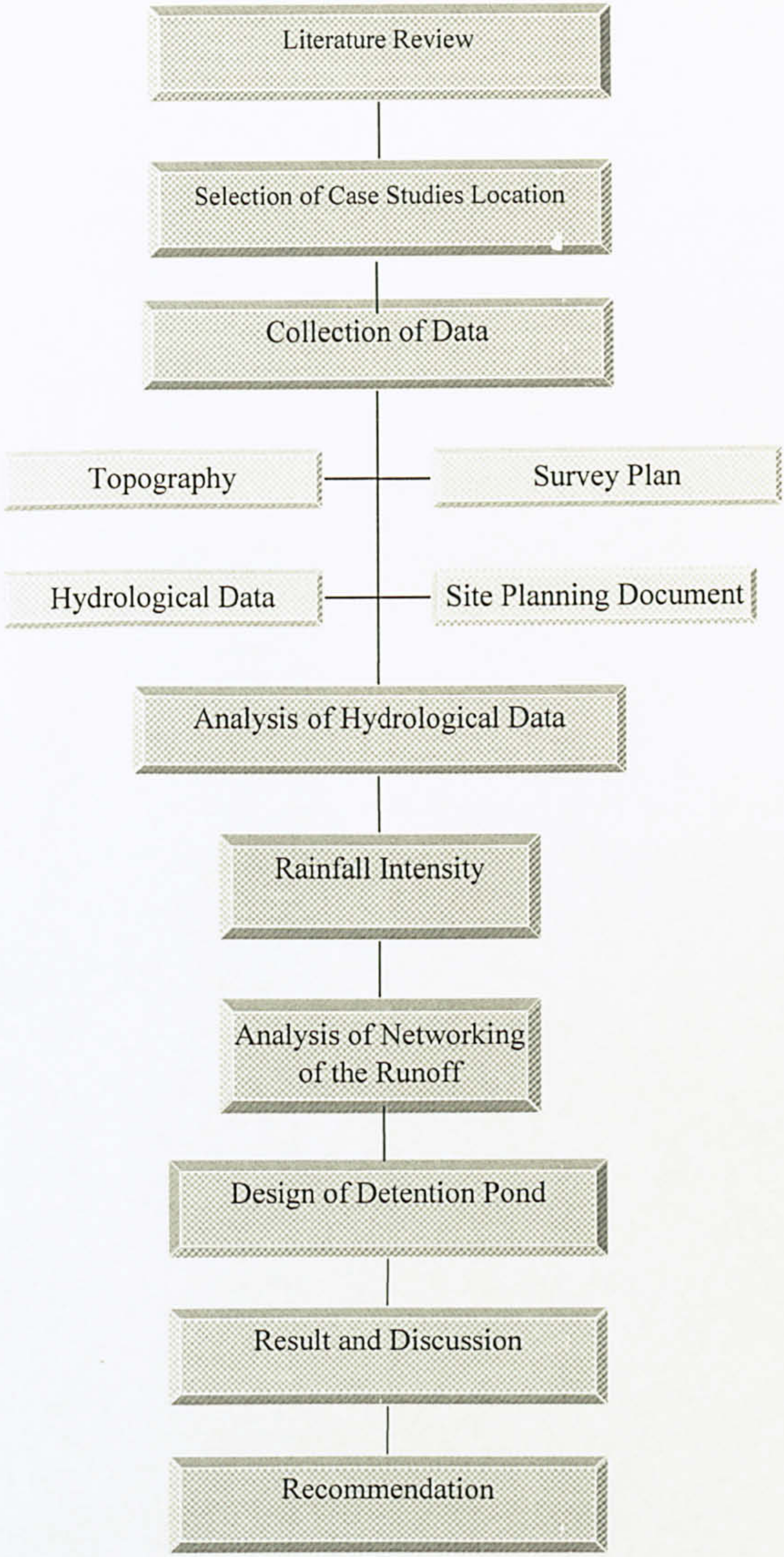

Figure 3.1: Research methodology flow chart

3.2 Basic Data

3.2.1 Project Area

The proposed project site for the case study covers Lot 5057, Lot 3873, Lot 7805, and Lot 11979 of Kamunting Raya area. It is located in the Larut Matang and Selama territory and situated about 10 km from Taiping Utara PLUS Toll. The proposed site is still on development programmed. The area will be developed into industrial area which mainly factories and some residential.

The area is about 200 hectares and the area is almost at the same level. This site is proposed as the project area because of the mining history. There are abundant of abandoned mining pond scattered all over the area. The specific area is focusing on mining pond which located in the middle of the area.

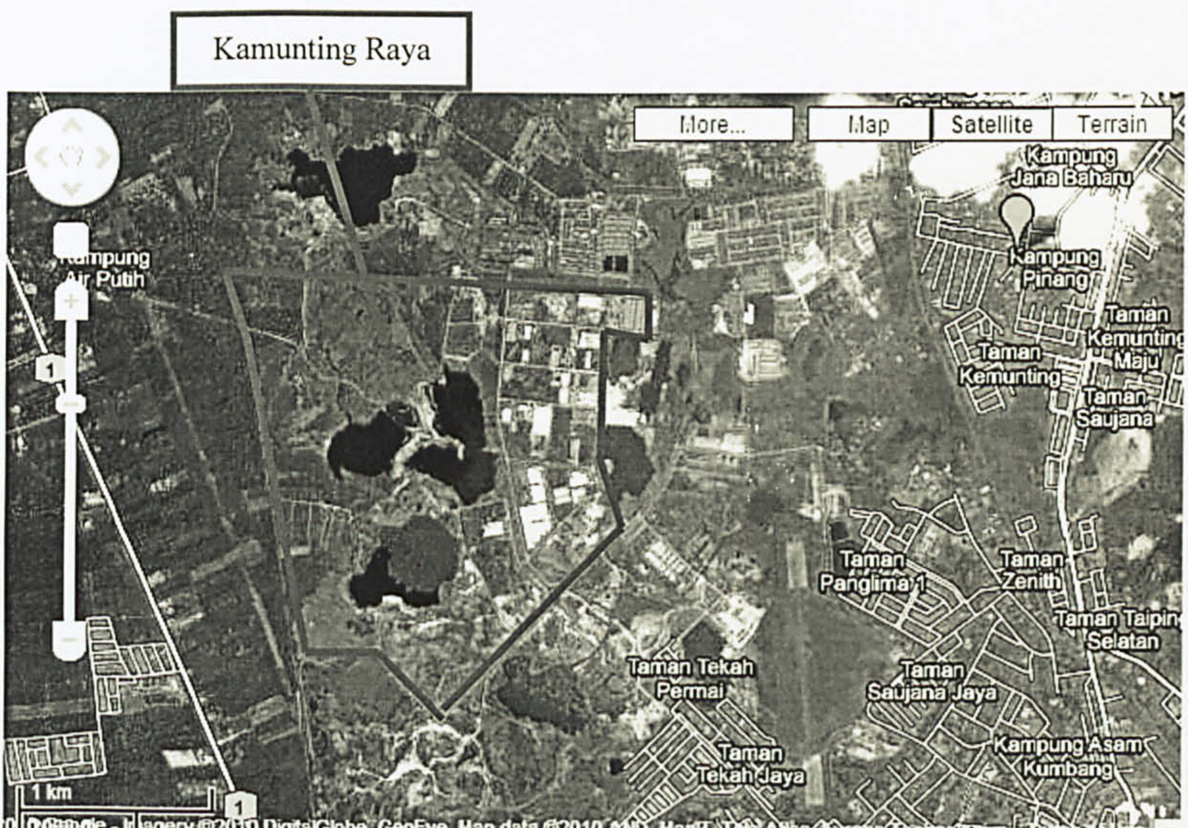

Figure 3.2: Satellite View of the Kamunting Raya Area

3.2.2 Data Available for Study

For specific land in Malaysia, local authority is given the power to control and manage the land. Therefore, for this project some local authority is consult for the legal data. Other than that, for the real experience of the site condition, the consultant and developer have to be consult. Below is the department of authority and the document that will be collect:-

Table 3.1: Correspondence and document

Correspondence	Document
JabatanPengairan dan Saliran (JPS)	• Rainfall tabulation form • Catchment area map
Majlis Perbandaran Taiping (MPT)	• Previous land use document • Planning document • Overall map
Consultant	• Previous calculation of Road and Drainage
Developer	• New development document

As overall catchment Jabatan Pengairan dan Saliran and Local Authority have to be consult. In regional cases the land use has been plan by local authority. The planning most base on local research that may be published by them. The data that can be collected at JPS and Local authority are survey plan, planning document of the specific area, hydrological data and information of the catchment of area involve.

3.3 Case Study

3.3.1 Planning

In order to consider the suitability of the case study, some consideration has been made as such the reliability of the data, the history of the site and also the location of the site. The real ex-mining pond has to be selected to be a case study. This case study will assure the real data and hands on for the project.

3.3.2 Field Work

Field work activities mainly involved in real observation of the mining pond. The site exploration will give the best indication for the design aspect. The data completion by field work is the best. Below is the figure of the site area:-

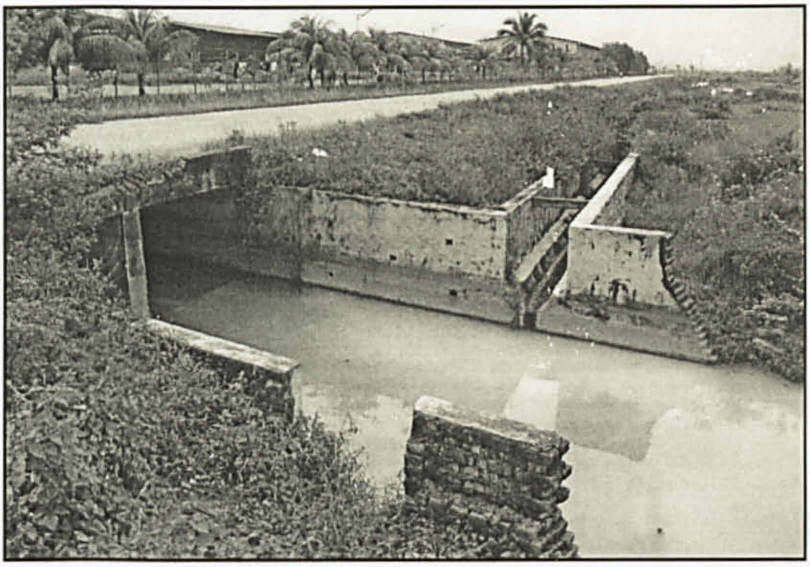

Figure 3.3: Inflow view of the study pond

Figure 3.4: Overall view of the study pond

3.4 Design Criteria

3.4.1 Hydrologic Analysis

3.4.1.1 Design Storm

Essentially rainfall is the main contributor of natural water resources. This rainfall will goes to the surface, into the soil and some will evaporate. In designing manually the intensity is solely taken which all the rainfall will go to the surface. The contribution in design stages is in term of the rainfall intensity. Intensity is indicate as I can be calculate using (Equation 3.1) :

Design Rainfall as indicate in MASMA:

$ln({}^{R}I_{t}) = a + bln(t) + c(ln(t))^{2} + d(ln(t))^{3}$ (4.1) where,

${}^{R}I_{t}$	= the average rainfall intensity (mm/hr) for ARI and duration
R	= average return interval (years)
t	= duration (minutes)

a to *d* are fitting constants dependent on ARI as in Table 13.2 in Appendix C.

Below is the procedure that needed to calculate the rainfall intensity:

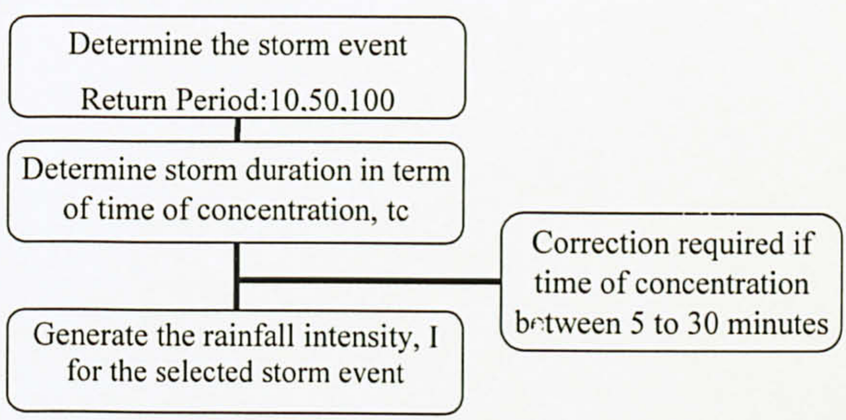

Figure 3.5: Procedure for design rainfall

3.4.1.2 Current Rainfall Data Analysis

The analysis is taking place from the rainfall tabulated data. The rainfall is analyse to get real rainfall indication of the catchment area. The method can be used which is Gumbel's Method. There are application Weibull Distribution which a versatile distribution that can take on the characteristics of other types of distributions.

3.4.1.3 Runoff Analysis

Peak discharge of the hydraulic analysis is calculated by using rational method. Produce discharge value which based on catchment area, runoff coefficient, C and rainfall intensity, I.

Rational method (Equation 3.2) as indicate in MASMA :

$$Q = \frac{CIA}{360}$$

C = the runoff coefficient,

I = is the rainfall intensity (mm/hr)

A = the catchment area (ha).

Below is a runoff analysis procedure:

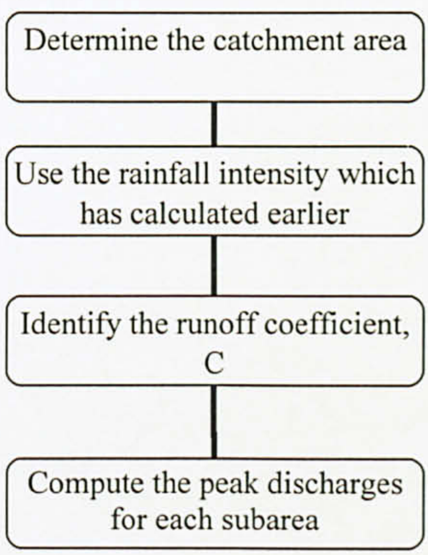

Figure 3.5: Procedure for design rainfall

3.4.2 Hydraulic Facilities Design

3.4.2.1 Drainage Design

1) Manual Calculation

Spreedsheet is use for the checking of calculation and some comparison can be made using this calculation. Almost all Consultancy Office implemented the Spreedsheet because of the clear output and understanding. The minima graphic and the input is clearly shows the continuous calculation. The input information and calculation of the spreadsheet is based on MASMA recommendation. Procedure of manual calculation:

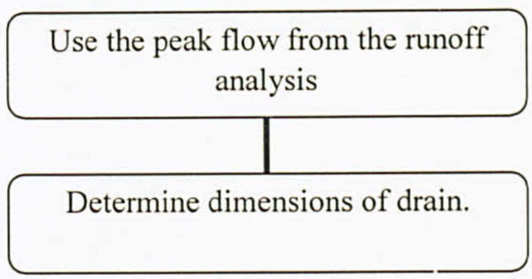

Figure 3.7: Procedure of drainage design (manual)

2) MIDUSS Configuration

Procedure for MIDUSS drainage design

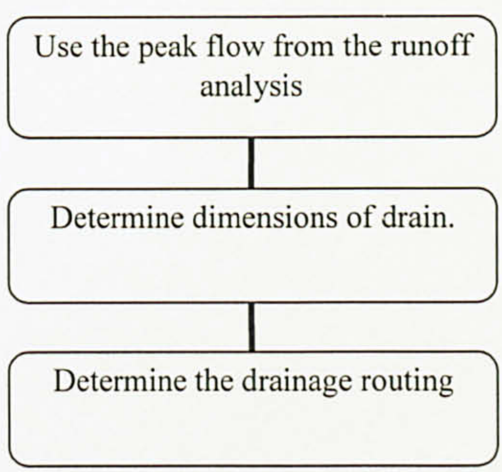

Figure 3.8: Procedure of drainage design (software)

3.4.2.2 Pond Design

Overall consideration will be made for the pond structure. The proposed and existing structure by the consultant has to analyze and a new calculation will be made to compare the finding of the quantity value of the study pond. For hydraulic structure the calculation is based on the existing mining pond that will be assess as the objective of this project.

1) Manual calculation

Different line of spreadsheet will be used which consider the pre and post development of the catchment area. Procedure for pond design is shown in Figure 3.9.

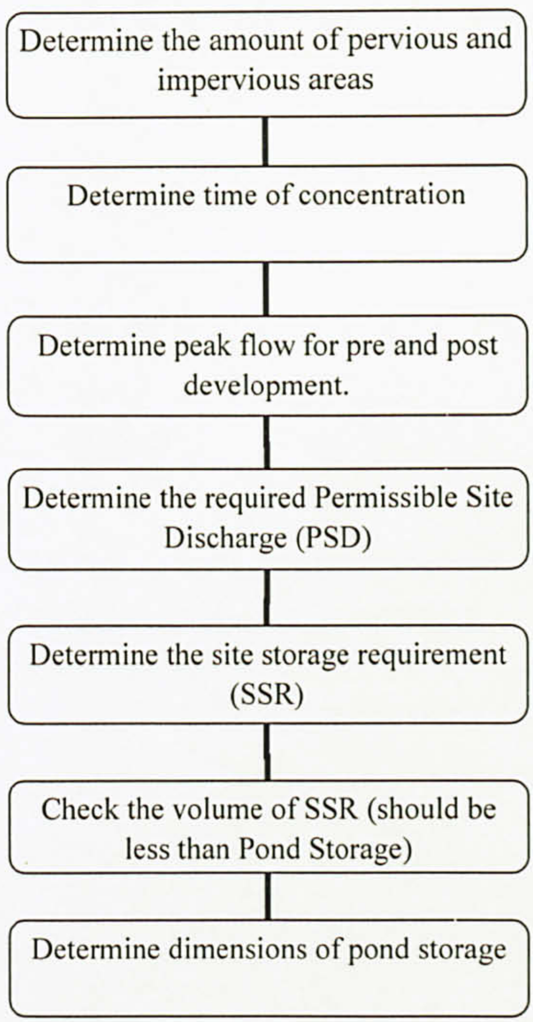

Figure 3.9: Procedure of pond design (manual)

2) MIDUSS Configuration

The computer aid may be used in analyzing and designing the drainage and retention pond for this project. The graphic and MASMA based calculation can be done for some modeling in order to get clear view of the project. There is a software which useful for this project. There are MIDDUS for Rainfall analysis and modeling of stormwater. Procedure for MIDUSS Modelling is shown in Figure 3.10:

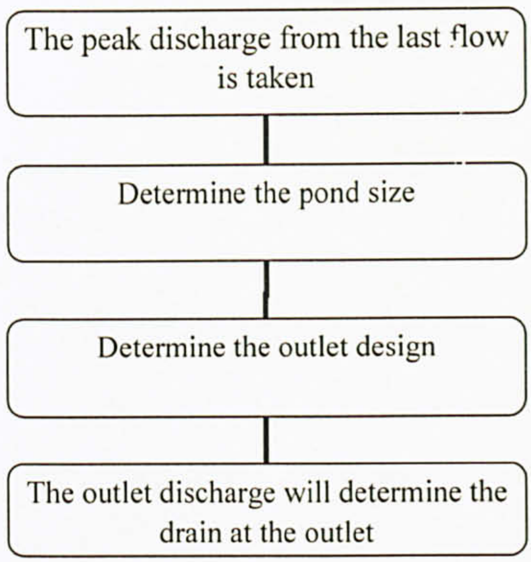

Figure 3.10: Procedure of pond design (software)

CHAPTER 4

RESULT AND DISCUSSION

4.1 Rainfall Analysis

4.1.1 Design Rainfall

For this project, design rainfall is used as suggested by MASMA. The storm duration use is 30 and 60 minutes as suggested. The adjustment factor is used for the time of concentration below 30 minutes. In appendix C is the adjustment factor table. Bagan Serai is chosen for the Design Rainfall as it is the nearest place from Taiping. Return period of 10 years ARI chosen because of the mix development and the return period 50 and 100 years ARI return period is done for checking purposes.

The Malaysian version of MIDUSS has an extra item in the Hydrology menu for design storms for use in Malaysia. Because of the input which using the same design rainfall, the return period can be chosen to be the same as manual calculation using the 10, 50 and 100 years ARI. The duration use for software calculation is 30 minutes. MIDUSS application is applicable for 2, 5, 10, 20, 50 and 100 years ARI. The design rainfall is used rather than current time series rainfall for MIDUSS application.

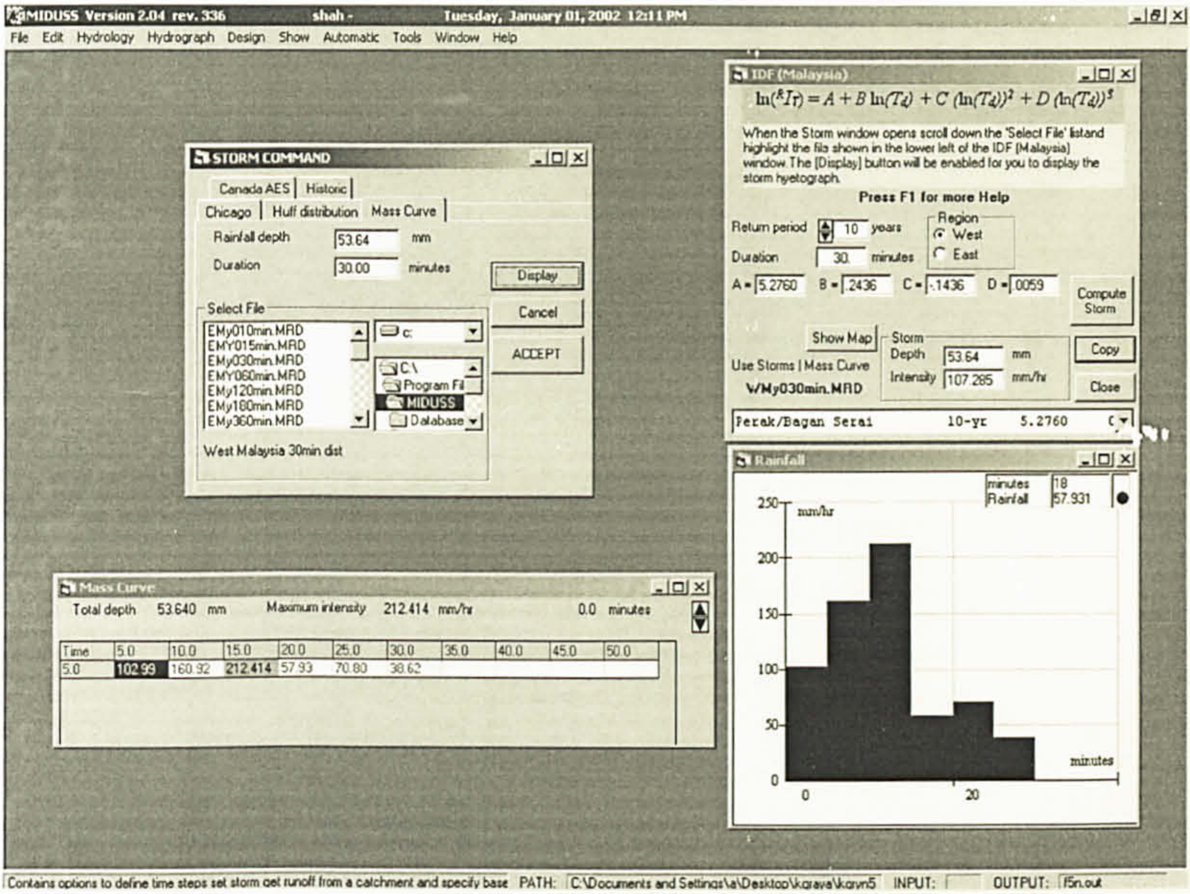

Figure 4.1: The calculation of design rainfall using MIDUSS software

4.1.2 Current rainfall analysis

The 30 years time series rainfall data has obtained from JPS. There is only one station of rainfall depth obtained which is from Bukit Larut Hydrological Station. It is a 24 hours rainfall depth that contributes to Taiping area. The data have been analyzed and Intensity of rainfall in the catchment is obtained. The data can be calculated in different statistical form but for this project only Gumbel's distribution is concentrated.

This method is concentrated on to find the Intensity of the place according to the return period. By using plotting position of Weibull method the result obtain as the return period of the rainfall magnitude. After considering Gumbel's method the value can be promoted to further design calculation.

Table 4.1 shows the average rainfall according to year. Table 4.2 is the results of the rainfall depth which have been analyze using Weibul s method. A semi log graph is use to tabulate the depth according to the return period. Extrapolation is made to obtain the depth of 50 and 100 years ARI.

Table 4.1: The rainfall annual data

YEAR	ANNUAL(mm)	YEAR	ANNUAL(mm)
1978	10.93	1993	13.15
1979	9.82	1994	10.53
1980	12.19	1995	12.49
1981	9.42	1996	13.29
1982	12.08	1997	12.21
1983	9.09	1998	11.42
1984	11.53	1999	15.60
1985	10.58	2000	11.80
1986	10.16	2001	9.16
1987	11.33	2002	10.37
1988	10.85	2003	23.88
1989	11.16	2004	12.31
1990	9.05	2005	10.32
1991	9.84	2006	10.26
1992	8.00	2007	10.90

Table 4.2: The rainfall analysis

30

m	D	Probability *P=m/(N+1)*	Return Period T=1/P (years)
1	23.88	0.03	31.00
2	15.60	0.06	15.50
3	13.29	0.10	10.33
4	13.15	0.13	7.75
5	12.49	0.16	6.20
6	12.31	0.19	5.17

7	12.21	0.23	4.43
8	12.19	0.26	3.88
9	12.08	0.29	3.44
10	11.80	0.32	3.10
11	11.53	0.35	2.82
12	11.42	0.39	2.58
13	11.33	0.42	2.38
14	11.16	0.45	2.21
15	10.93	0.48	2.07
16	10.90	0.52	1.94
17	10.85	0.55	1.82
18	10.58	0.58	1.72
19	10.53	0.61	1.63
20	10.37	0.65	1.55
21	10.32	0.68	1.48
22	10.26	0.71	1.41
23	10.16	0.74	1.35
24	9.84	0.77	1.29
25	9.82	0.81	1.24
26	9.42	0.84	1.19
27	9.16	0.87	1.15
28	9.09	0.90	1.11
29	9.05	0.94	1.07
30	8.00	0.97	1.03

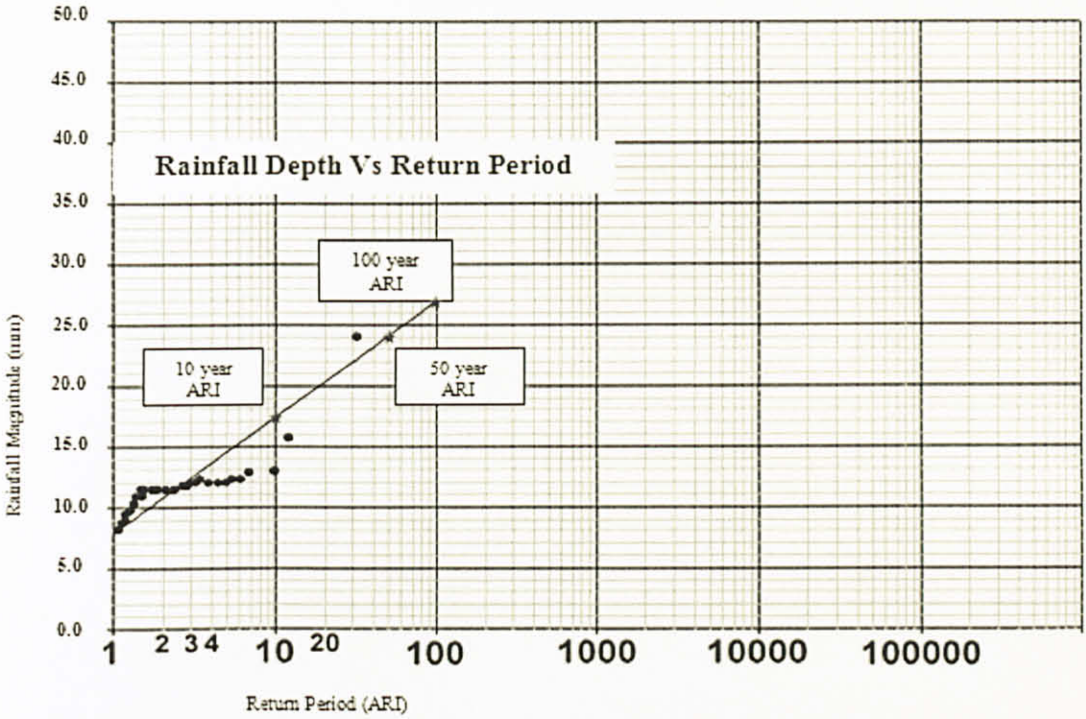

Figure 4.2: The rainfall depth according to the return period

From Figure 4.2 depth of 10, 50 and 100 years ARI is obtained. The depth is converted into intensity by dividing into 30 days times 24 hour.

For 10 years ARI the Intensity:
Depth =17mm
Intensity, I =17/(30*24) =0.02361mm/hr

For 50 years ARI the Intensity:
Depth =24mm
Intensity, I =24/(30*24) =0.00333mm/hr

For 100 years ARI the Intensity:
Depth =27mm
Intensity, I =27/(30*24) =0.03750mm/hr

The advantage of the time series rainfall data analysis is the depth is clearly shown according to the return period. However, the analysis method can be to straight forward and the result of the Intensity is much lower than the design rainfall. In addition, 24 hour rainfall duration is too long. Therefore, more comprehensive statistical analysis has to carry out based of the data. The method using for this project have limitation and further calculation have to be made.

4.2 Networking Analysis

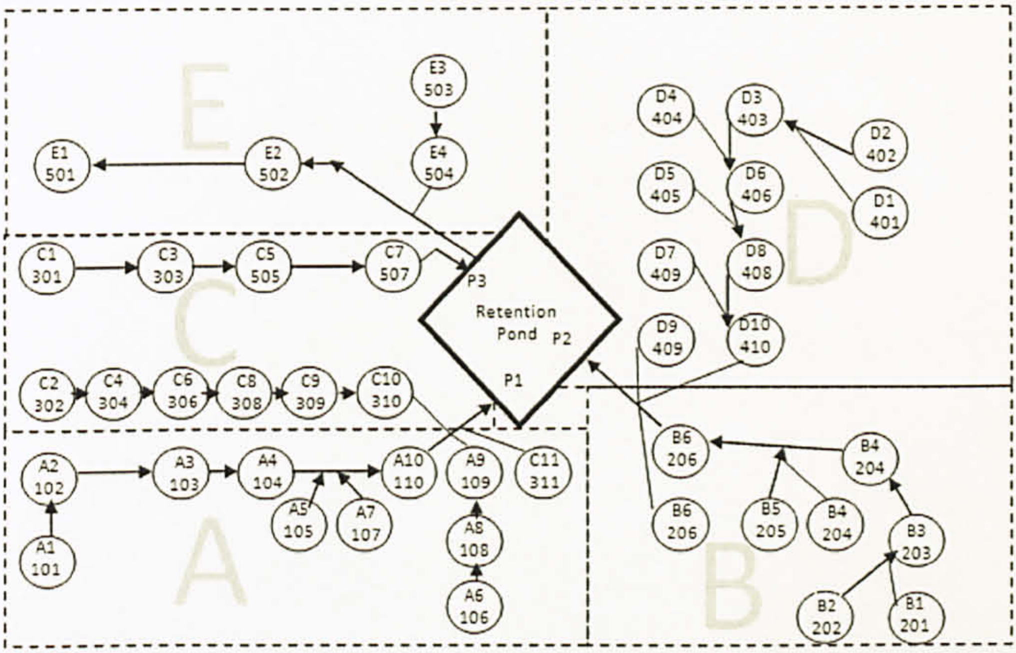

Figure 4.3: The connection diagram

The drainage area of Kamunting Raya is connected to each other. The connection is manually drafted to configure the flow of the connected drain. As for the retention pond, the connection is link with 3 inlets and one outlet from the catchment area. The area is given name by A, B, C, D and E as a group. Catchment E is however did not contribute the runoff to the pond.

After doing the analysis, the drain flow and length can be define and further used to satisfy the calculation of drainage design. The flow has been listed in appendix C. For this area main drain, culvert and retention pond is taken for the facilities design. The main drain will cater the runoff stormwater for the larger area. The P1, P2 and P3 are the inlet to the retention pond. The peak discharge shown at the comparison Table 4.4. The final discharge for the overall area is at Sungai Air Putih.

4.3 Catchment Area Data

The catchment area data is preliminary data that will be used to calculate the peak discharge of the area. The catchment area defines as area that contributes water of the runoff quantities. The data needed are catchment area (hectare(s)), runoff coefficient (C), and time of concentration, t_c (hours). The data has been listed in Appendix B .

The area basically is taken from the catchment flow which defines from the survey plan. It is noted that the flow from urban area is contribute higher peak discharge as the surface runoff is tactically faster.

4.4 Physical Evaluation of Abandoned Mining Pond

Mining pond is a natural pond. The depth is greater than other man made pond. The depth of the pond is about 15m. Therefore, a lot of consideration is carried out. General limitations are adapted from MASMA Volume 8 is analyzed to evaluate the physical characteristic of the pond. Table 4.3 shows the requirement from MASMA and the description from the abandoned mining pond observation in order to comply with the requirement.

Table 4.3: The physical criteria evaluation of retention pond (Adapted from MASMA 2000)

Criteria	MASMA Requirement	Abandoned Mining Pond
1) Soil Suitability	• No limitation on soil infiltration rate but a minimum rate of 13 mm/hr is recommended. • Soil with greater clay content or 40% greater silt/clay content shall not be used. • Infiltration systems shall neither utilize fill material nor be placed over fill soils.	• No limitation of soil infiltration. • The soil is consist of sandy soil. • The system use is natural and no fill material is utilized.
2) Depth to Bedrock, Water Table, or Impermeable Layer, or Dissimilar Soil Layer	• All facilities shall be located at least 1.5m above the seasonal high ground water mark, bedrock (or hardpan) and/or impermeable layer. • Infiltration basin required low water table.	• These criteria have been implemented. The level of the building is increase by 2m. • A high water table can inhibit infiltration and indicate the potential for ground water contamination.
3) Proximity to Drinking Water Wells, Septic Tanks, Drain fields, Building Foundations, Structures and Property Lines	• Infiltration facilities on commercial and industrial sites at least 35m from drinking water wells, septic tanks or drainfields and spring used for public drinking water supplies. • Infiltration facilities should be situated at least 7m downslope and 50m from building foundations.	• Building is located more than 100 m from the retention pond. • This system is compulsory according to building bye-law. • The planner have been plan the building placement before construction.

4) Land Slope	• Avoid application of infiltration practices on a steep grade. • Infiltration facilities can be located on slopes up to 15% only.	• The site area is almost flat whereby the gradient is approximately 0.001.
5) Drainage Area	• Infiltration BMPs are limited in their ability to accept flows from larger drainage areas. • Infiltration basin – maximum of 15 hectares	• The overall catchment area is about 200 hectare. • The catchment area has been divided according to the inlet. • Therefore, there should be sufficient for the area above 15 hectares.
6) Control of Siltation	• Infiltration facilities should be the final construction for the development area • The site has to be properly stabilized with permanent erosion control. • Pretreatment (BMP) should be provided.	• There is bare soil is left because of in progress development. • Vegetative will be implemented.

Other than that, there is some requirement that needed to be proposed for the retention pond to be valid. The sizing have to be specific according to the design calculation. The construction part have to be monitor and safeguard. In term of maintenance the clogging, slope stability effects on groundwater have to be monitor and maintain to avoid any complication of hazard after the implementation.

4.5 Hydraulics Facilities Design

The purpose to come out with retention pond design is to know the dimension and capacity of design retention pond. The quantity estimation will be compare with the natural mining pond capacity to achieved second objective of this report. Starting with drainage facilities, the design will be tabulated.

4.5.1 Drainage design

4.5.1.1 Manual Calculation

In using manual calculation, the drainage design is adapted using MASMA manual. 2 types of Rainfall intensity is used for this design purposes. The first design is using the design storm which recommended by MASMA and secondly the current rainfall data which have been calculated previously. For mixture development, the return period of 10 years is required. The time of concentration which has been investigated earlier needed in the calculation using design storm. In current rainfall calculation, the rainfall intensity is being use directly in to the calculation.

Next, rational method is used for calculating the peak discharge of the drain. The peak discharge is compared to the given drain capacity to know the real size of the drain. The connected flow the catchment is taken into account which in Catchment A there is link of catchment. The pattern is that the first catchment will have smaller drain size compare to the last catchment which link to the retention pond.

The final product of this design is the dimension of the drain that will be used for the project area. The result is in appendix C.

4.5.1.2 MIDUSS Configuration

Percentage of previous and impervious catchment is specified. The drainage system is design for post development. Impervious percentage to be taken as up to 50% for Kamunting Raya area. Figure 4.3 shows the input item for the catchment and the runoff graph. The peak discharge is calculated from this input data. Figure 4.5 show the current peak flow that have been calculated and the design of the channel for the specific catchment.

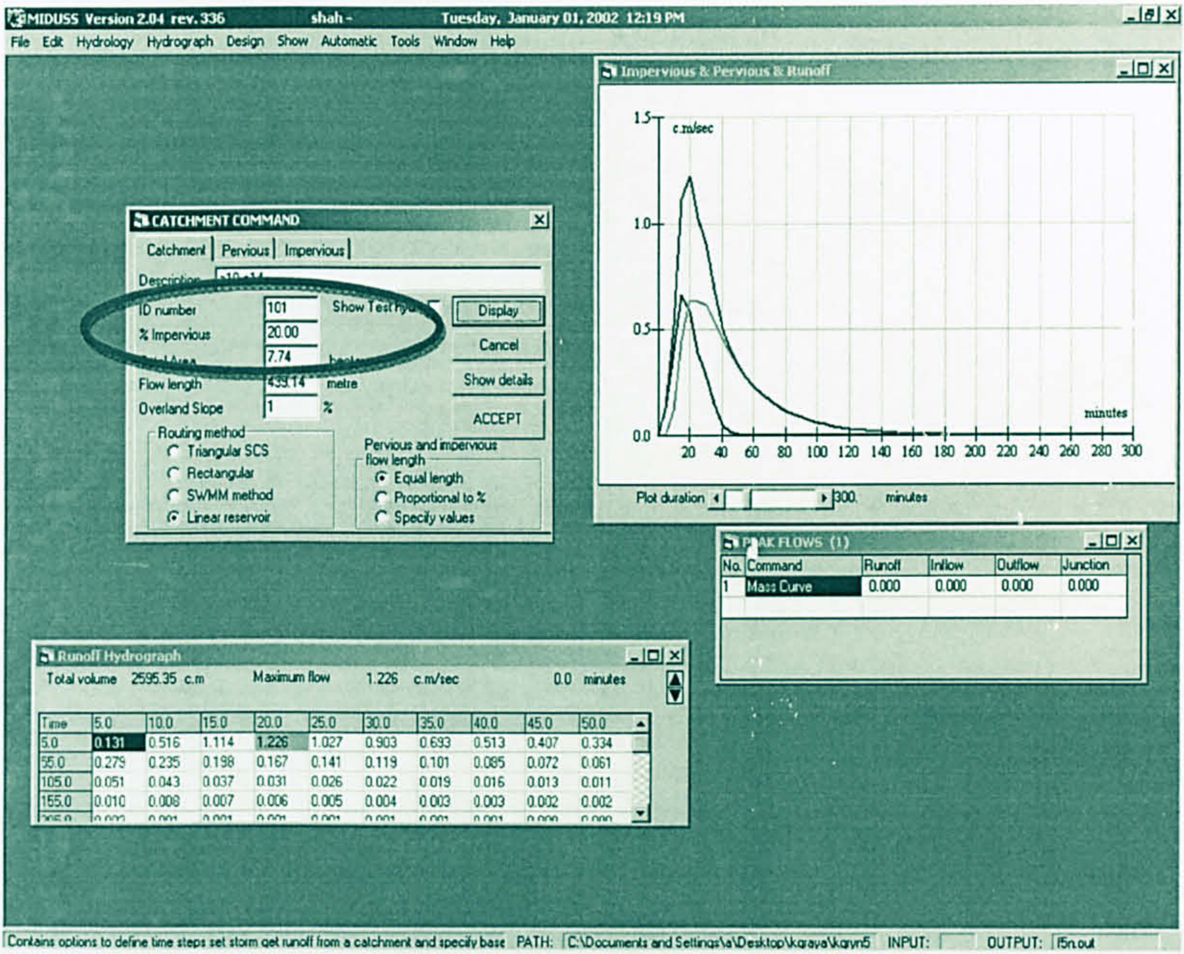

Figure 4.4: The catchment input command

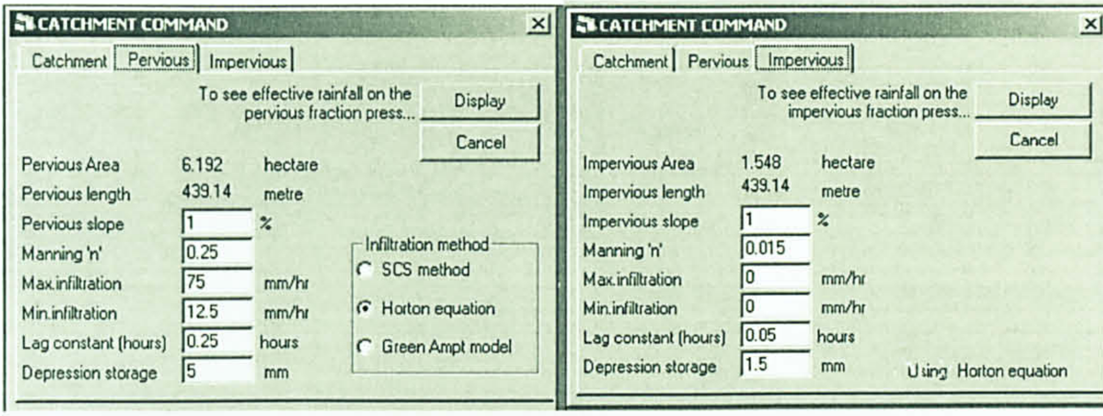

Figure 4.5: The pervious and impervious input command

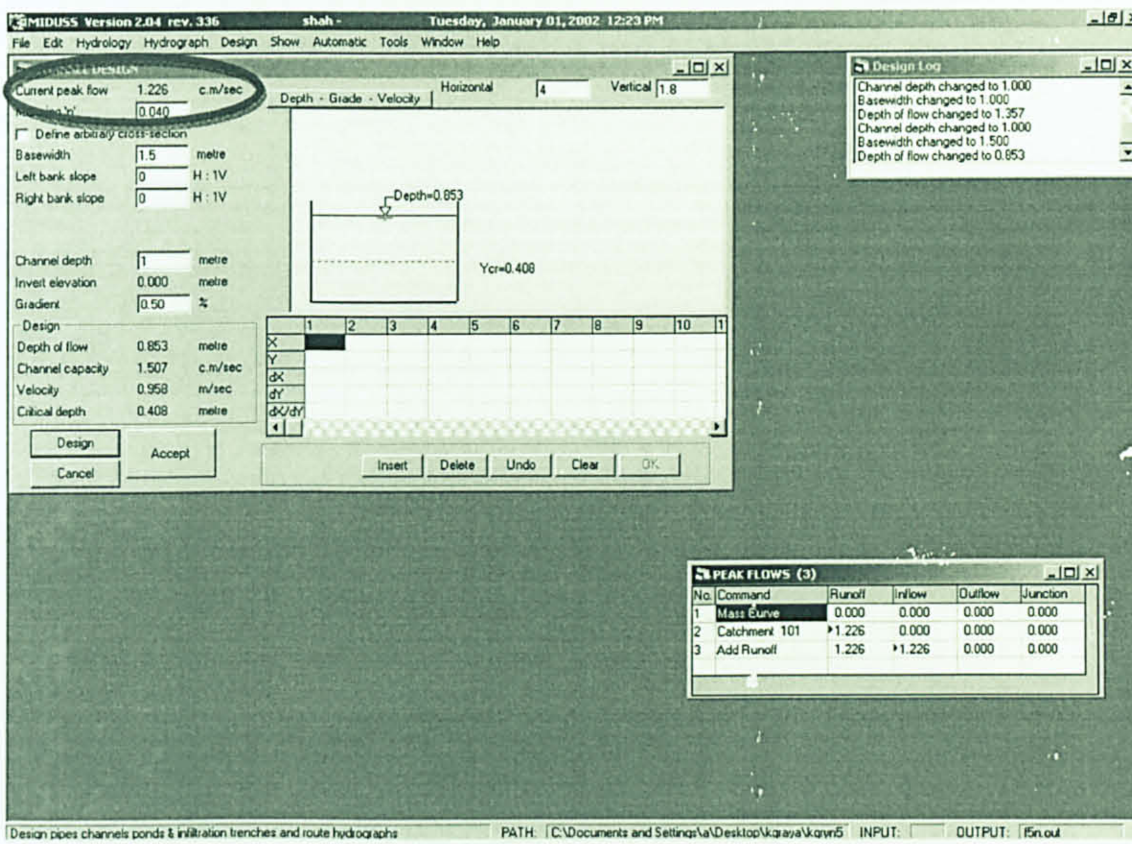

Figure 4.6: The channel design according to the current peak flow

4.5.2 Pond Design

4.5.2.1 Manual Calculation

For the pond design the volume is calculated based on the Site Storage Requirement (SSR) and Permissible Storage Discharge requirement. The calculation is attached at the appendix. From the result obtained, abandoned mining pond is sufficient to cater the stormwater for the overall catchment.

The inlet of the discharge is assumed to be in one inlet. The overall catchment gives a conventional number of peak discharges for the pond. The pond is design solely based on the peak discharge that has been calculated. Therefore, the pond volume is higher but still under volume when compare with the volume of the abandoned mining pond.

4.5.2.1 MIDUSS Configuration

MIDUSS design utilizes the final peak discharge. The method is continuous from the channel design. This design gives the volume that has to be provided for the catchment area. The following diagrams are the print screen view of the design that runs by MIDDUS.

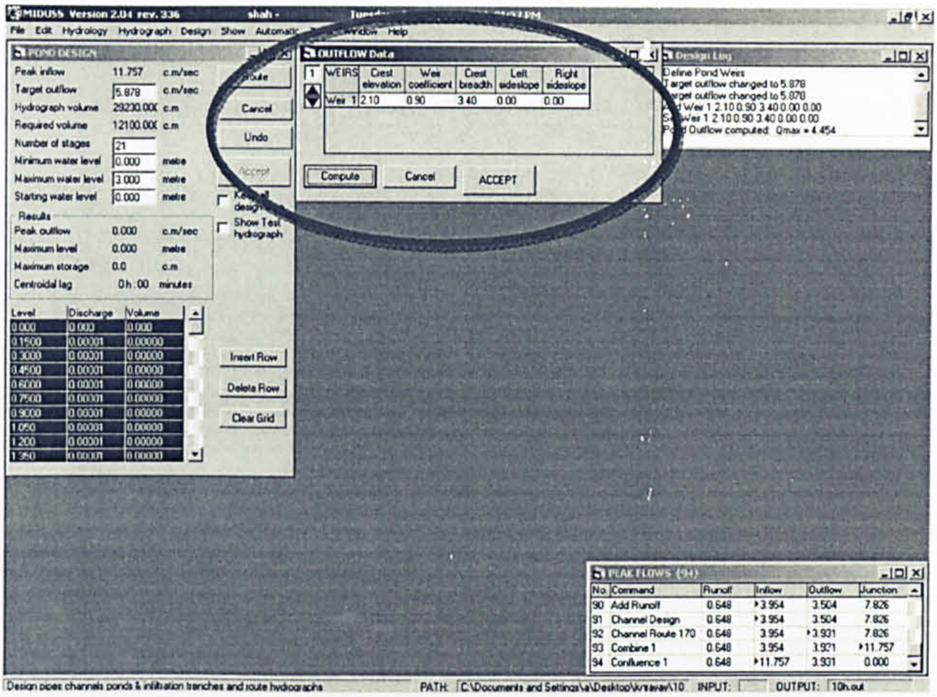

Figure 4.7: The weir calculation using MIDUSS

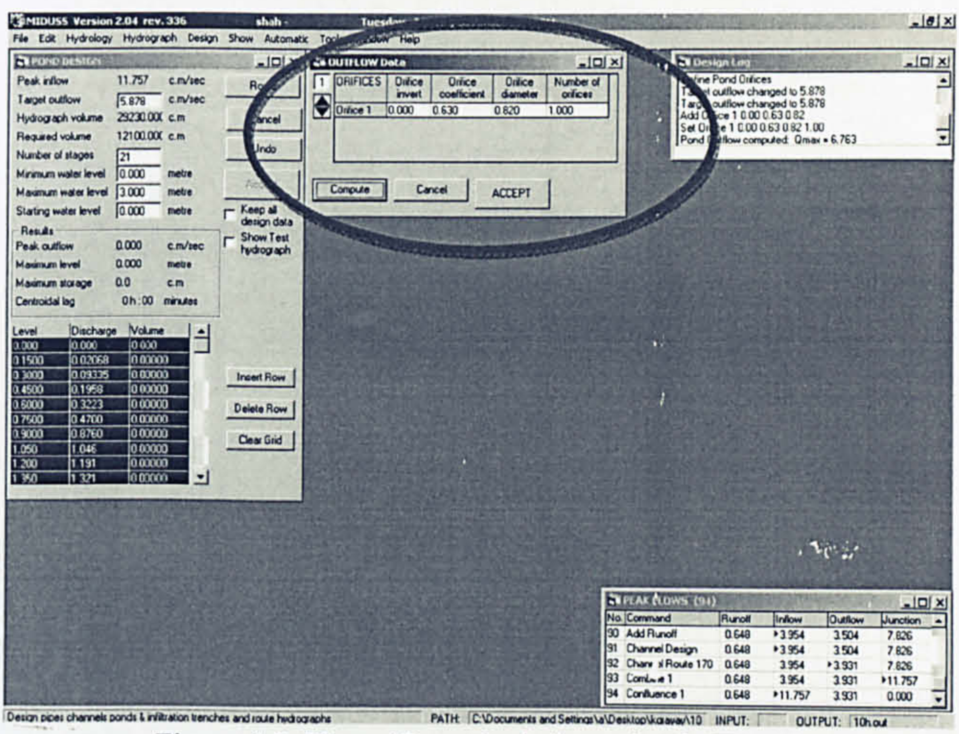

Figure 4.8: The orifice calculation using MIDUSS

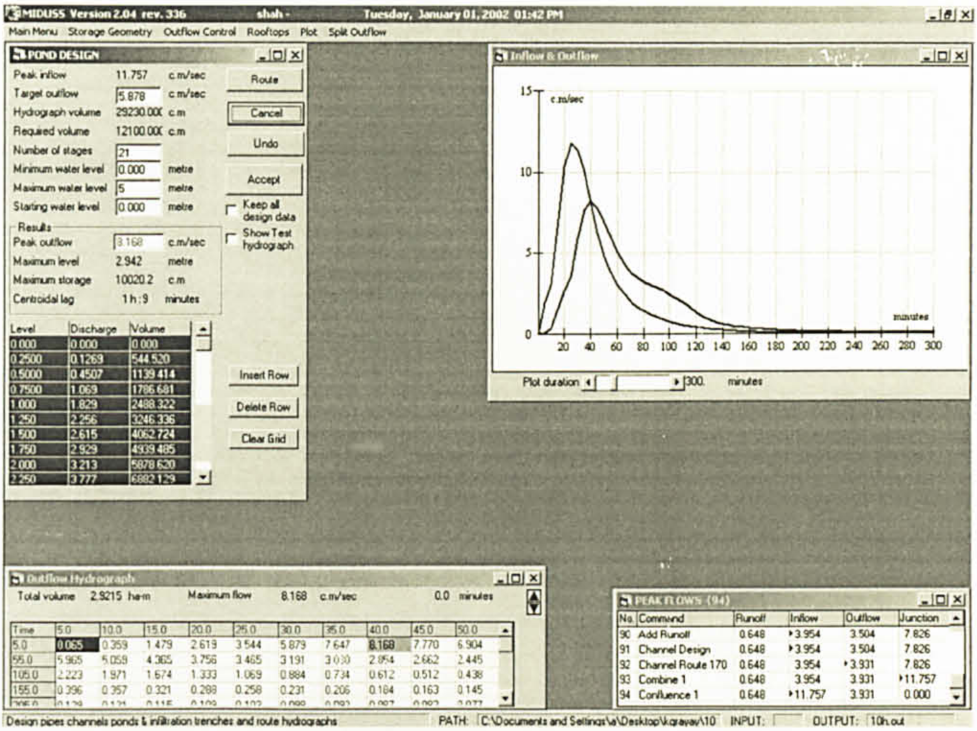

Figure 4.9: The pond design using MIDUSS

4.6 Comparison of Design between MASMA, MIDDUS Modeling and Current Rainfall

Finally, the result is compared in the table form. There are 3 type of methods is used to analyze and design the overall catchment facilities of Kamunting Raya area. Table 4.4 is the comparison of these three methods.

Table 4.4: The Comparison of Design Parameter of MASMA and MIDUSS Modelling.

NO.	PARAMETER/DESIGN CHARACTERISTIC	UNIT	MASMA			MIDUSS MODELLING		CURRENT RAINFALL INTENSITY		
1.0	Rainfall Design									
	1.1 Storm Event	year								
	Drainage System		10, 50,100			10,50,100		10,50,100		
	Pond System		10, 50, 100			10,50,100		10,50,100		
	1.2Design Rainfall Curve	mm/hr	IDF			IDF		Gumbel's Distribution		
2.0	Time of concentration, t_c	min								
	2.1Pre-development		30-60			Default by 30		Not applicable		
	2.2Post-development									
	2.3Formula									
	• Overland time, t_o	min	Friend's formula			-		Not applicable		
	• Drain time, t_d		Length/Velocity							
3.0	Peak Discharge, Qpeak Post-development	m^3/s	P1	P2	P3	INFLOW	OUTFLOW	P1	P2	P3
	10 years ARI		4.261	7.102	3.781	11.757	8.168	0.001	0.001	0.001
	50 years ARI		5.355	8.905	4.750	18.719	6.475	0.001	0.001	0.001
	100 years ARI		5.994	10.05	5.313	22.087	7.566	0.002	0.001	0.001

4.0	Runoff Hydrograph		-	Unit Hydrograph	-
5.0	Pond Size for 10 years ARI	m m m	5 100 500	5 100 24	Not applicable
6.0	Volume of the pond for 10 years ARI	m^3	250000	12100	Not applicable
7.0	Pond Routing		-	Muskingam's Method	-

4.7 Comparison of design between MASMA, MIDDUS peak discharge

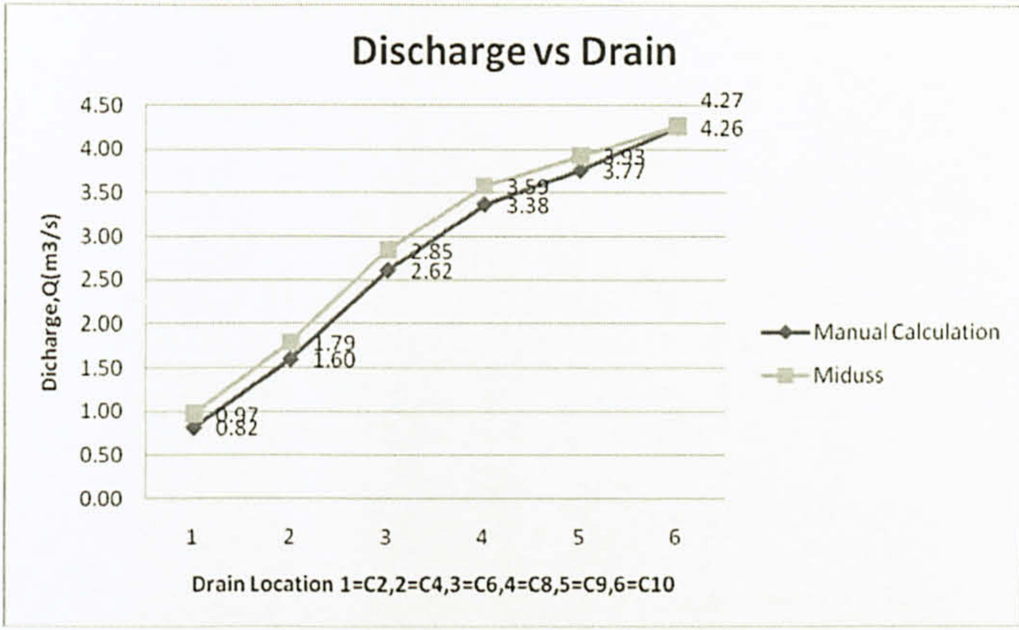

Figure 4.10: The Comparison between MIDUSS and Manual Calculation for a selected link no.1

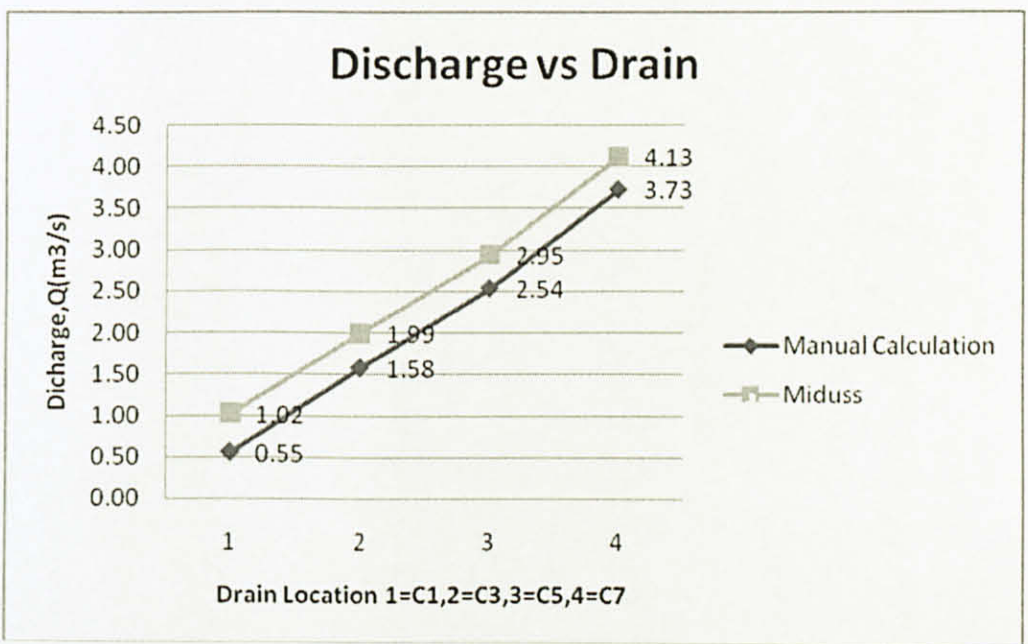

Figure 4.11: The Comparison between MIDUSS and Manual Calculation for a selected link no.2

Graph of selected drain versus the discharge is comparing the MIDUSS calculated peak discharge with manually calculated peak discharge. The graph above shows that the manual calculation and MIDUSS calculated peak discharge obtained slightly higher than manual calculation is conventional from manual calculation.

CHAPTER 5

CONCLUSION AND RECOMMENDATION

The case study confirms that the pond chosen for the catchment area is suitable. Being in the lowest part of the catchment area. Facilitates gravity flow of water quality through drainage channels. It has sufficient size and capacity to cater for the design storm discharge and out flowing natural outlet of adequate size.

The application of MIDUSS software is recommended for its easy to use feature, low cost, widely used by local authorities and Jabatan Pengaliran dan Saliran (JPS) in Malaysia for checking drainage design, submission of drainage plan but it is also capable of being customized to Malaysian practice (MASMA).

Jabatan Pengaliran dan Saliran has not yet to publish IDF curve for Taiping town. It is recommended further studies on the rainfall data to derive IDF curve for Taiping. It is too rigorous and time consuming to incorporate in this case study.

With the information available in this case study it is recommended that futher study should be made on the quality aspect of the discharge in the future as the continuation for this thesis.

Although MASMA was published ten years ago, (year 2000) unfortunately its application falls behind time. It is world class manual but it fails to deliver. It is hope that all universities in Malaysia should include MASMA in its syllabus to equip engineers to fully utilize this procedure in the future.

If Malaysia desires to be well developing nation by 2020, the government should elevate the status of MASMA from a recommended best practice to an act of parliament.

MIDDUSS is widely used in Malaysia for storm water design and management. University Technology of Petronas should undertake to introduce the software to its student or even collaborate with MIDDUSS to improve the application performance.

University Technology of Petronas should includes in its curriculum, the Malaysian practice for submission and approval of development plans by authorities in Malaysia.

Abandoned mining ponds usually viewed negatively. It is timely to shift this negative perception to a positive view where with proper planning, proper design of storm water management system, and suitable layout for ıand use. Ex mining pond soon will a be prime real estate master piece for the future while generating revenue for the state government.

It is timely that River Basin Management Plan (RBMP) be established, regulated, enforced and implemented to optimize and control land use development for a given catchment.

Advancing technologies facilitate the mean for controlling rain at its source. University technology of Petronas should pioneer the study of controlling storm from its formation in the cloud and control rainfall distribution as per demand.

CHAPTER 6

ECONOMIC BENEFIT

The 592-acre of land had been plans to be completed with drainage facilities and a retention pond. Initially, this project is mainly on design basis and the prime resource is for the software cost. The software is used to get the high economic value of the drainage facilities of the project area. For this project MIDUSS software is used where the function is Malaysian customized. The costing quantity will be much more significant in the construction and maintenance stages.

There are many benefit gain after implementing the urban drainage design which develop in this project. The runoff input and output can be calculated and control. As we know flood is the natural disaster that always concern the community. The remediation of the disaster will taken lots of monies. Therefore, the urban design is important beneficial for the long term runoff management in term flood control. In addition, upstream runoff will be control by the retention pond which the discharge reduces at the downstream. Therefore, the design for the downstream will be small and economical.

Development leads to an increase in the amount of pollutants in an area. Sediment from construction sites can end up in streams and rivers, choking plant and animal life. Chemical solution from the manufacturing activity will polluted the source of water in the area. Therefore, the quality management which introduce by the urban runoff management system will decrease the pollutant.

When designed and sited correctly, retention pond can help developers not just reduce negative environmental impacts caused by the development process but also increase the value of the property. Urban runoff management controls can be incorporated into a development in a way that provides aesthetic and economic benefits. Urban runoff systems with standing water often appear to be natural systems. A clean lake or pond offers benefits to developers by creating an ideal setting for model units and for the sales office. Many ponds planned for urban runoff control are also designed to provide recreational facilities.

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APPENDICES

APPENDIX A

APPENDIX

RAINFALL DEPTH (MM) IN YEAR 1978
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	0.0	0.0	15.0	75.0	0.0	0.0	42.0	0.0	0.0	0.0	10.0	0.0	
2	0.0	0.0	0.0	1.0	16.5	0.0	0.0	0.0	0.0	19.0	35.0	12.0	
3	0.0	0.0	23.0	0.0	10.0	0.0	2.0	0.0	25.0	0.0	15.0	0.0	
4	0.0	0.0	0.0	37.0	0.0	17.5	0.0	0.0	82.0	0.0	6.0	5.0	
5	0.0	0.0	0.0	0.0	5.0	151.0	0.0	0.0	32.0	44.0	4.0	0.0	
6	0.0	40.0	0.0	25.0	22.0	0.0	0.0	0.0	18.0	2.0	42.0	0.0	
7	0.0	20.0	0.0	54.0	25.0	30.0	5.5	0.0	4.0	19.0	0.0	2.5	
8	5.0	2.0	43.0	36.0	14.0	0.0	0.0	0.0	0.0	0.0	27.0	0.0	
9	17.0	0.0	9.0	15.0	40.0	0.0	0.0	4.0	0.0	10.0	15.0	8.0	
10	5.0	0.0	13.0	0.0	0.0	8.0	0.0	0.0	18.0	0.0	0.0	36.0	
11	7.0	0.0	6.0	0.0	45.0	2.5	0.0	0.0	0.0	45.0	0.0	0.0	
12	5.0	5.0	2.0	36.0	31.0	0.0	54.0	0.0	8.0	15.0	20.0	0.0	
13	7.0	4.5	0.0	0.0	20.5	0.0	0.0	6.0	0.0	18.0	37.5	0.0	
14	0.0	0.0	0.0	15.0	0.0	0.0	3.0	3.0	0.0	8.5	64.5	0.0	
15	25.0	38.0	0.0	20.0	0.0	0.0	0.0	0.0	26.0	3.0	2.5	2.0	
16	15.0	0.0	0.0	0.0	0.0	8.0	0.0	14.0	0.0	0.0	28.0	2.0	
17	47.0	16.0	185.0	4.5	0.0	0.0	63.5	3.5	0.0	0.0	0.0	0.0	
18	62.0	0.0	16.0	4.0	0.0	0.0	0.0	0.0	0.0	10.0	6.0	53.0	
19	0.0	0.0	0.0	57.0	0.0	10.0	0.0	0.0	0.0	47.0	10.0	0.0	
20	0.0	0.0	30.0	44.0	83.0	0.0	0.0	0.0	15.0	45.0	0.0	5.0	
21	0.0	0.0	17.0	55.0	80.0	0.0	0.0	21.0	0.0	5.0	0.0	8.0	
22	0.0	118.0	25.0	51.0	6.0	0.0	40.0	0.0	9.0	9.0	0.0	0.0	
23	37.0	10.0	0.0	0.0	0.0	10.0	11.0	0.0	14.5	2.0	5.0	0.0	
24	0.0	0.0	31.0	35.0	0.0	0.0	0.0	0.0	0.0	63.5	0.0	0.0	
25	0.0	0.0	0.0	29.0	0.0	0.0	28.0	5.5	0.0	20.0	0.0	5.0	
26	0.0	0.0	17.5	14.0	0.0	0.0	0.0	0.0	0.0	15.0	0.0	0.0	
27	0.0	83.0	0.0	0.0	10.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
28	0.0	7.5	0.0	0.0	0.0	0.0	0.0	12.0	0.0	35.0	0.0	0.0	
29	0.0	0.0	0.0	0.0	0.0	68.0	0.0	0.0	0.0	3.5	0.0	11.0	
30	40.0	0.0	0.0	40.0	0.0	0.0	0.0	6.0	0.0	35.0	0.0	8.0	
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	22.5	0.0	10.0	
SUM	272.0	344.0	432.5	647.5	408.0	305.0	249.0	76.0	251.5	496.0	327.5	167.5	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		8.77	12.29	13.95	21.58	13.16	10.17	8.03	2.45	8.38	16.00	10.92	5.40
						10.93							

RAINFALL DEPTH (MM) IN YEAR 1979
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	0.0	0.0	0.0	5.0	3.0	55.0	0.0	0.0	50.0	0.0	1.0	0.0	
2	0.0	0.0	0.0	10.0	88.0	3.0	0.0	0.0	62.0	0.0	10.0	0.0	
3	0.0	0.0	23.0	28.0	2.0	20.0	0.0	0.0	95.0	0.0	0.0	18.0	
4	0.0	0.0	0.0	98.0	0.0	0.0	0.0	0.0	31.0	0.0	8.0	32.0	
5	0.0	3.0	0.0	2.0	18.0	0.0	0.0	10.0	17.0	0.0	53.0	3.0	
6	0.0	0.0	4.5	12.0	35.0	12.0	25.0	0.0	3.0	13.5	6.5	12.0	
7	0.0	4.5	30.0	4.0	15.0	31.0	0.0	0.0	5.0	3.0	1.5	0.0	
8	0.0	0.0	0.0	0.0	0.0	29.0	0.0	0.0	25.0	6.5	38.0	0.0	
9	0.0	0.0	0.0	0.0	1.5	34.0	0.0	0.0	23.5	0.0	13.5	0.0	
10	6.0	0.0	0.0	5.0	0.0	0.0	0.0	0.0	19.5	0.0	100.0	0.0	
11	0.0	21.0	0.0	5.5	0.0	0.0	3.0	0.0	0.0	35.0	0.0	1.0	
12	0.0	0.0	0.0	83.0	2.0	11.5	0.0	0.0	42.0	7.0	22.0	43.0	
13	0.0	5.0	0.0	3.0	0.0	10.0	19.5	0.0	2.0	11.5	7.5	0.0	
14	0.0	1.0	5.0	0.0	0.0	0.0	0.0	0.0	11.0	19.0	0.0	8.0	
15	0.0	15.0	1.0	0.0	0.0	0.0	0.0	0.0	23.0	45.0	2.0	0.0	
16	0.0	24.0	12.0	0.0	0.0	0.0	0.0	0.0	20.0	10.0	100.0	0.0	
17	0.0	0.5	3.5	0.0	0.0	0.0	10.0	0.0	10.0	5.0	38.0	0.0	
18	0.0	14.0	0.0	10.0	0.0	21.0	22.0	2.0	0.0	24.0	105.0	0.0	
19	0.0	11.5	0.0	10.0	0.0	0.0	0.0	37.0	0.0	0.0	8.0	13.0	
20	0.0	0.0	25.0	12.0	0.0	15.0	80.0	7.0	0.0	54.0	3.5	0.0	
21	0.0	0.0	0.0	30.0	0.0	0.0	30.0	26.0	0.0	3.0	80.0	0.0	
22	0.0	0.0	0.0	0.0	22.0	0.0	25.0	3.0	0.0	51.0	5.5	3.5	
23	0.0	0.0	7.0	0.0	0.0	0.0	0.0	0.0	0.0	15.0	7.0	3.0	
24	0.0	9.0	0.0	7.0	0.0	15.0	0.0	0.0	0.0	17.0	0.0	0.0	
25	0.0	8.0	0.0	68.0	0.0	0.0	22.0	0.0	0.0	5.0	0.0	0.0	
26	0.0	23.0	20.0	5.0	8.0	0.0	5.0	18.0	0.0	5.0	13.5	0.0	
27	0.0	22.5	0.0	28.0	12.0	0.0	0.0	10.0	0.0	55.0	85.0	0.0	
28	0.0	0.0	0.0	22.0	9.5	9.5	0.0	4.0	0.0	4.0	0.0	4.0	
29	0.5	0.0	28.0	26.0	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	
30	12.5	0.0	25.0	5.0	30.0	0.0	0.0	35.0	0.0	20.5	5.5	0.0	
31	0.0	0.0	65.0	0.0	0.0	0.0	0.0	48.0	0.0	6.0	0.0	0.0	
SUM	19.0	162.0	249.0	478.5	246.0	266.0	241.5	202.0	439.0	415.0	714.0	140.5	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		0.61	5.79	8.03	15.95	7.94	8.87	7.79	6.52	14.63	13.39	23.80	4.53
						9.82							

RAINFALL DEPTH (MM) IN YEAR 1980
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS
1	10.5	0.0	7.0	0.0	12.0	15.0	23.5	0.0	0.0	7.0	3.5	12.0
2	0.0	0.0	42.0	0.0	1.0	5.0	0.0	3.0	0.0	134.0	6.0	2.0
3	0.0	0.0	11.0	43.0	61.0	34.5	0.0	16.0	0.0	0.0	15.0	3.0
4	0.0	4.0	0.0	0.0	20.0	72.0	0.0	22.5	0.0	7.0	4.0	2.0
5	0.0	0.0	24.0	17.0	80.0	54.0	0.0	0.0	45.0	14.0	24.0	3.0
6	0.0	0.0	23.0	63.0	5.0	0.0	0.0	15.0	0.0	20.0	25.5	25.0
7	4.0	0.0	20.0	7.0	10.0	1.0	0.0	42.0	1.0	3.0	25.5	6.0
8	0.0	0.0	36.0	2.0	12.0	0.0	0.0	10.0	0.0	13.0	15.0	84.0
9	0.0	0.0	0.0	30.0	0.0	0.0	64.5	36.0	25.0	27.0	24.0	28.0
10	0.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	2.5	54.0	6.5	0.0
11	1.5	0.0	44.0	4.0	17.0	0.0	5.0	5.0	10.0	17.0	7.0	0.0
12	6.0	0.0	25.0	15.0	6.0	11.0	0.0	10.0	0.0	2.5	5.0	20.5
13	27.0	0.0	7.0	0.0	6.0	70.0	15.0	0.0	0.0	12.0	6.0	0.0
14	*0.0*	*7.0*	*5.0*	*12.0*	*80.0*	*0.0*	*21.0*	*0.0*	*0.0*	*8.5*	*2.0*	*0.5*
15	0.0	10.0	43.0	0.0	2.0	0.0	18.0	2.0	0.0	11.0	29.0	45.0
16	0.0	0.0	14.0	4.0	1.0	0.0	105.0	37.0	7.5	54.0	20.0	0.0
17	0.0	0.0	6.0	13.0	0.0	1.5	18.0	0.0	27.0	2.0	4.0	2.0
18	0.0	0.0	54.5	0.0	0.0	0.0	0.0	5.0	83.0	0.0	92.0	11.0
19	0.0	0.0	50.0	7.0	0.0	0.0	0.0	33.0	0.0	28.0	6.0	35.0
20	0.0	0.5	0.0	5.0	0.0	0.0	9.0	23.0	79.0	30.0	9.0	15.0
21	67.0	21.0	6.0	0.0	0.0	0.0	0.0	20.0	32.0	2.0	21.0	75.0
22	4.0	44.5	87.0	0.0	0.0	2.0	0.0	5.0	35.0	0.0	10.5	3.5
23	0.0	33.0	2.0	21.0	0.0	0.0	0.0	3.0	49.0	4.0	0.0	2.0
24	0.0	4.0	0.0	3.5	12.0	7.5	0.0	0.0	7.0	0.0	9.0	2.0
25	32.0	0.0	16.5	8.0	4.0	0.0	0.0	0.0	5.0	3.0	0.0	0.0
26	36.0	0.0	0.0	11.0	3.0	0.0	0.0	0.0	11.0	0.0	121.5	10.0
27	0.0	15.0	3.0	8.0	10.5	0.0	0.0	0.0	20.0	3.0	4.0	3.0
28	*0.0*	*0.0*	*30.0*	*12.0*	*25.0*	*0.0*	*0.0*	*0.0*	*50.0*	*4.5*	*0.0*	*5.0*
29	0.0	95.0	2.0	6.0	0.0	0.0	0.0	27.0	0.0	1.0	0.0	33.5
30	0.0	0.0	8.0	5.0	20.0	0.5	0.0	0.0	1.0	5.0	0.0	12.0
31	0.0	0.0	0.0	0.0	7.0	0.0	19.0	0.0	0.0	0.0	0.0	0.0
SUM	188.0	234.0	566.0	298.5	394.5	274.0	298.0	314.5	490.0	466.5	495.0	440.0
no of days ©	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)	6.06	8.36	18.26	9.95	12.73	9.13	9.61	10.15	16.33	15.05	16.50	14.19

12.19

RAINFALL DEPTH (MM) IN YEAR 1981
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS
1	8.0	55.0	0.0	17.0	18.0	15.0	0.0	0.0	3.0	0.0	16.5	0.0
2	4.0	22.0	0.0	45.0	18.0	0.0	0.0	0.0	35.0	0.0	20.0	0.0
3	0.0	75.5	0.0	5.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	17.0	2.0	8.0	25.0	0.0	0.0	0.0	31.0	0.0	19.0	1.0
5	17.5	18.5	0.0	52.0	6.0	0.0	0.0	0.0	5.0	20.0	13.5	30.0
6	10.5	5.0	0.0	28.0	72.0	0.0	0.0	0.0	53.0	17.5	20.0	1.0
7	15.0	0.0	0.0	32.5	0.0	0.0	0.0	0.0	41.0	23.0	0.0	0.0
8	65.0	0.0	2.5	7.0	76.0	0.0	0.0	0.0	0.0	22.0	20.0	0.0
9	10.0	3.0	3.0	12.0	2.0	2.0	19.0	0.0	5.5	0.5	2.0	0.0
10	5.0	0.0	2.5	3.0	26.0	0.0	0.0	0.0	9.0	0.0	0.0	0.0
11	4.0	0.0	0.0	2.0	0.0	0.0	0.0	0.0	9.5	0.0	0.0	0.0
12	0.0	10.0	0.0	0.0	0.0	0.0	17.0	0.0	53.0	0.0	8.0	0.0
13	0.0	35.0	4.0	11.0	66.0	0.0	0.0	0.0	2.0	27.5	2.0	0.0
14	*0.0*	*80.0*	*9.0*	*3.5*	*130.0*	*0.0*	*2.0*	*0.0*	*5.0*	*18.0*	*0.0*	*1.0*
15	0.0	3.0	0.0	11.5	0.0	0.0	18.0	0.0	0.0	0.2	0.0	0.0
16	0.0	0.0	0.0	6.5	18.0	0.0	0.0	0.0	35.0	60.0	0.0	0.0
17	0.0	0.0	0.0	16.5	10.0	0.0	1.0	0.0	0.0	3.0	0.0	0.0
18	0.0	0.0	0.0	95.0	10.5	0.0	2.0	2.0	0.0	0.1	15.0	0.0
19	0.0	0.0	2.0	13.0	5.0	0.0	0.0	9.0	3.0	0.0	9.0	0.0
20	0.0	26.0	29.0	42.0	0.0	0.0	0.0	0.0	0.0	16.5	14.0	0.0
21	0.0	13.0	30.0	6.0	10.0	0.0	0.0	0.0	15.0	0.0	5.0	0.0
22	0.0	0.0	0.0	0.0	10.0	0.0	3.0	0.0	5.0	38.0	0.0	0.0
23	15.5	8.0	25.0	7.0	2.0	0.0	16.0	35.0	3.0	0.0	0.0	0.0
24	0.0	15.0	22.0	0.0	0.0	3.0	10.0	0.0	3.5	12.0	0.0	0.0
25	0.0	5.0	0.0	0.0	7.0	46.0	0.0	0.5	3.0	0.0	0.0	0.0
26	0.0	35.0	0.0	16.0	30.0	1.0	0.0	8.5	3.0	15.0	20.0	0.0
27	0.0	53.0	2.0	15.0	11.5	31.0	2.0	0.0	0.0	73.5	19.0	0.0
28	*1.0*	*40.0*	*0.0*	*0.0*	*31.0*	*38.0*	*2.0*	*2.0*	*0.0*	*0.0*	*7.0*	*0.0*
29	0.0	0.0	0.0	27.0	0.0	0.0	22.0	0.0	0.0	20.0	3.0	3.0
30	0.0	0.0	0.0	14.0	17.0	0.0	1.0	19.0	0.0	16.0	0.0	27.0
31	0.0	0.0	27.0	0.0	116.0	0.0	0.0	6.5	0.0	16.5	0.0	10.0
SUM	155.5	519.0	160.0	495.5	739.0	136.0	115.0	82.5	322.5	399.3	213.0	73.0
no of days ©	31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)	5.02	18.54	5.16	16.52	23.84	4.53	3.71	2.66	10.75	12.88	7.10	2.35

9.42

RAINFALL DEPTH (MM) IN YEAR 1982
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	0.0	1.0	55.0	0.0	0.0	0.0	0.0	0.0	52.5	25.0	34.0	16.5	
2	0.0	5.5	0.0	9.5	6.0	65.0	0.0	12.0	5.0	21.5	0.0	30.0	
3	0.0	0.0	0.0	36.5	7.0	0.0	59.0	7.5	0.0	11.5	0.0	0.0	
4	0.0	0.0	0.0	37.5	2.5	13.0	0.0	47.0	0.0	27.0	18.0	0.0	
5	0.0	0.0	0.0	50.5	18.0	0.0	77.0	0.0	0.0	9.5	77.0	0.0	
6	0.0	5.0	0.0	80.0	2.0	0.0	0.0	1.0	0.0	0.0	8.0	0.0	
7	0.0	100.0	0.0	30.5	18.0	0.0	0.0	0.0	0.0	12.0	47.0	0.0	
8	0.0	8.0	10.0	0.0	57.0	0.0	0.0	27.0	0.0	5.0	6.0	8.0	
9	0.0	3.0	5.0	10.0	0.0	0.0	50.0	0.0	0.0	15.0	30.0	0.0	
10	0.0	0.0	26.5	32.5	20.0	0.0	2.0	0.0	0.0	0.0	3.0	2.0	
11	0.0	0.0	10.0	9.0	56.0	2.0	13.5	90.0	0.0	0.0	80.0	18.0	
12	0.0	5.0	0.0	45.0	0.0	1.5	0.0	0.0	0.0	0.0	34.0	0.0	
13	0.0	72.0	0.0	23.0	2.0	3.0	2.0	0.0	19.0	57.0	0.0	2.5	
14	2.5	0.0	0.0	6.0	40.0	0.0	0.0	2.0	0.0	54.0	40.0	8.5	
15	*18.0*	*0.0*	*0.0*	*10.5*	*0.0*	*0.0*	*0.0*	*0.0*	*26.0*	*5.5*	*0.0*	*0.0*	
16	0.0	0.0	0.0	4.0	4.0	0.0	0.0	21.0	0.0	46.0	21.5	23.0	
17	0.0	0.0	0.0	8.0	2.0	0.0	20.0	0.0	25.0	0.0	0.0	10.0	
18	0.0	20.0	20.0	4.0	13.0	0.0	46.0	12.0	3.0	0.0	18.5	3.0	
19	0.0	0.0	0.0	5.0	3.5	0.0	0.0	7.0	9.5	11.5	23.0	9.0	
20	0.0	0.0	0.0	65.0	27.0	0.0	0.0	0.0	7.0	4.0	87.0	0.0	
21	0.0	0.0	0.0	22.5	0.0	5.0	0.0	11.0	10.0	5.0	33.0	0.0	
22	0.0	14.0	14.0	40.0	4.0	62.0	43.0	0.0	28.0	3.0	17.0	0.0	
23	18.0	5.5	5.5	2.0	2.5	0.0	1.5	0.0	13.0	0.0	2.5	0.0	
24	10.0	6.0	6.0	45.0	0.0	0.0	1.0	15.5	23.0	11.0	3.0	0.0	
25	48.0	0.0	0.0	2.0	19.5	0.0	11.0	0.0	0.0	0.0	17.0	0.0	
26	0.0	0.0	0.0	46.0	2.0	0.0	2.0	0.0	42.0	15.0	32.0	0.0	
27	10.0	10.5	10.5	23.0	8.0	0.0	0.0	0.0	10.0	6.0	35.0	48.0	
28	0.0	7.0	7.0	24.5	45.0	0.0	0.0	3.0	69.5	22.0	18.0	42.5	
29	*0.0*	*0.0*	*0.0*	*10.5*	*0.0*	*0.0*	*0.0*	*0.0*	*40.0*	*15.0*	*36.0*	*98.0*	
30	10.0	0.0	0.0	125.0	0.0	0.0	0.0	15.0	33.0	28.0	0.0	20.0	
31	0.0	0.0	0.0	0.0	6.0	0.0	0.0	4.5	0.0	32.0	0.0	5.0	
SUM	116.5	262.5	169.5	807.0	365.0	151.5	328.0	275.5	415.5	441.5	720.5	344.0	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		3.76	9.38	5.47	26.90	11.77	5.05	10.58	8.89	13.85	14.24	24.02	11.10
						12.08							

RAINFALL DEPTH (MM) IN YEAR 1983
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	5.0	1.0	0.0	0.0	1.5	24.0	0.0	24.0	42.0	0.0	0.0	3.5	
2	18.0	0.0	0.0	19.5	87.0	0.0	0.0	17.0	44.5	0.0	4.0	0.2	
3	45.0	2.0	0.0	0.0	0.0	36.0	0.0	50.0	13.0	0.0	0.0	0.2	
4	0.0	0.0	2.0	2.0	40.0	8.0	0.0	5.0	14.0	0.0	5.0	4.0	
5	0.0	0.0	0.0	0.0	73.0	0.0	0.0	15.0	14.0	13.5	2.0	16.0	
6	0.0	0.0	1.5	0.0	0.0	0.0	7.0	0.0	24.0	3.0	3.0	13.0	
7	2.0	0.0	0.0	0.0	14.0	0.0	0.0	0.0	13.5	0.0	0.0	4.0	
8	0.0	0.0	0.0	0.0	6.0	0.0	12.5	0.0	18.0	3.0	0.0	0.0	
9	0.0	38.0	7.0	0.0	74.0	0.0	33.0	0.0	65.0	2.0	0.0	0.0	
10	0.0	13.0	16.0	4.0	67.0	0.0	2.0	0.0	5.0	0.0	0.0	0.2	
11	7.0	0.0	11.5	1.5	6.5	20.0	0.0	27.0	22.0	0.0	27.0	4.0	
12	0.0	10.0	4.5	0.0	7.0	26.0	18.5	0.0	3.0	0.0	0.0	0.0	
13	0.0	0.0	29.5	0.0	38.0	5.0	5.5	0.0	15.0	5.5	83.0	18.5	
14	*0.0*	*18.0*	*40.0*	*0.0*	*0.0*	*13.0*	*0.0*	*0.0*	*44.0*	*35.0*	*0.0*	*2.0*	
15	0.0	11.0	2.0	1.5	28.0	10.0	3.0	3.0	83.0	13.0	4.5	5.5	
16	0.0	0.0	0.0	0.0	0.0	4.0	0.0	0.0	0.0	4.0	42.5	32.5	
17	0.0	0.0	5.0	0.0	1.0	3.0	0.0	0.0	13.5	38.0	0.0	0.5	
18	0.0	46.0	8.0	0.0	18.5	2.0	32.0	0.0	28.0	0.0	0.0	0.0	
19	0.0	97.0	75.0	0.0	3.0	0.0	15.0	10.0	50.0	70.0	0.0	0.0	
20	0.0	0.0	6.0	0.0	11.0	1.0	34.0	2.0	0.0	41.5	0.0	0.0	
21	0.0	5.0	11.0	14.0	31.0	0.0	0.0	32.0	0.0	45.0	0.0	4.0	
22	0.0	2.0	21.0	23.5	2.0	0.0	2.5	8.0	0.0	0.0	0.0	0.0	
23	0.0	3.5	0.0	25.5	2.0	0.0	3.5	0.0	0.0	0.0	0.0	0.0	
24	0.0	0.0	0.0	3.0	11.5	0.0	0.0	10.0	0.0	0.0	0.0	0.0	
25	0.0	8.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	0.0	13.0	
26	19.0	0.0	3.0	0.0	10.0	0.0	0.0	6.0	0.0	0.0	0.0	40.0	
27	0.0	23.5	0.0	0.0	8.0	0.0	0.0	2.5	7.5	0.0	9.5	0.0	
28	*0.0*	*0.0*	*1.5*	*0.0*	*0.0*	*0.0*	*3.0*	*26.5*	*0.0*	*0.0*	*19.0*	*0.0*	
29	1.0	0.0	0.0	25.0	0.0	85.0	15.0	0.0	35.0	25.0	6.5	21.0	
30	0.0	0.0	6.0	79.0	2.0	0.0	0.0	0.0	10.0	10.0	0.0	3.0	
31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	0.0	0.0	0.0	
SUM	97.0	278.0	250.5	198.5	542.0	237.0	186.5	257.0	564.0	310.5	206.0	185.1	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		3.13	9.93	8.08	6.62	17.48	7.90	6.02	8.29	18.80	10.02	6.87	5.97
						9.09							

RAINFALL DEPTH (MM) IN YEAR 1984
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	7.0	8.5	0.0	0.0	0.0	71.0	0.0	3.0	0.0	0.0	0.0	5.0	
2	3.0	58.0	2.0	6.0	20.5	9.0	0.0	4.0	34.0	0.2	14.0	2.0	
3	0.0	7.5	37.0	0.0	26.5	8.0	15.0	0.0	0.0	124.0	24.5	14.0	
4	0.0	6.0	0.0	0.0	0.0	18.0	0.0	0.0	26.5	47.0	25.0	3.0	
5	8.0	14.0	0.0	0.0	0.0	0.0	0.0	2.5	7.5	0.2	0.0	60.0	
6	0.0	0.0	0.0	0.0	0.0	0.0	20.0	14.5	37.0	0.0	24.0	80.0	
7	0.0	15.0	0.0	0.0	4.0	0.0	40.0	0.0	10.0	22.0	67.0	71.0	
8	0.0	23.0	0.0	40.0	20.0	0.0	0.0	0.0	0.0	5.0	0.0	11.0	
9	0.0	11.0	0.0	80.0	0.0	0.0	0.0	0.0	0.0	30.0	39.0	7.0	
10	0.0	0.0	0.0	0.0	30.5	0.0	0.0	0.0	0.0	3.5	6.0	0.0	
11	0.0	9.0	0.0	0.0	15.0	0.0	15.0	0.0	27.0	10.0	100.0	8.5	
12	3.0	25.0	0.0	8.0	20.5	0.0	114.0	0.0	8.0	0.0	55.0	52.0	
13	40.0	25.0	5.0	0.0	10.0	50.0	50.0	0.0	18.5	0.0	0.0	5.5	
14	15.0	0.0	0.0	49.0	26.5	0.0	48.0	0.0	0.0	0.0	12.0	20.0	
15	22.0	0.0	0.0	0.0	0.0	0.0	19.0	0.0	3.0	0.5	40.0	23.0	
16	5.0	16.0	51.0	0.0	9.0	38.0	42.0	0.0	0.0	0.0	10.0	31.5	
17	2.5	0.0	40.0	15.0	13.5	0.0	2.0	0.0	0.0	0.0	43.5	27.0	
18	2.5	12.0	3.5	20.0	0.0	0.0	80.0	0.0	0.0	1.0	30.0	0.0	
19	0.0	0.0	0.0	19.0	0.0	40.0	5.0	0.0	0.0	0.0	23.0	0.0	
20	3.0	0.0	65.0	9.0	0.0	0.0	5.0	0.0	9.0	15.0	38.0	0.0	
21	46.5	0.0	0.0	0.0	0.0	0.0	0.0	35.0	30.0	0.0	32.0	0.0	
22	12.0	0.0	55.0	0.0	45.0	0.0	0.0	3.5	0.0	15.0	0.0	0.0	
23	20.0	0.0	20.0	0.0	0.0	5.5	20.0	0.0	0.0	0.0	0.0	40.0	
24	55.0	4.5	15.0	0.0	0.0	0.0	0.0	10.0	0.0	6.0	0.0	0.0	
25	28.0	57.0	41.0	47.0	0.0	0.0	0.0	11.0	0.0	8.0	0.0	0.0	
26	0.0	0.0	34.0	0.0	0.0	0.0	0.0	0.0	0.0	7.0	0.0	2.5	
27	0.0	24.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	12.0	
28	0.0	0.0	0.0	0.0	0.0	2.5	0.0	0.0	0.0	10.0	0.0	30.0	
29	21.5	0.0	73.0	0.0	22.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
30	0.0	0.0	47.0	45.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
31	10.0	0.0	49.0	0.0	0.0	0.0	0.0	0.0	0.0	45.0	0.0	0.0	
SUM	304.0	315.5	537.5	338.0	263.0	242.0	475.0	83.5	210.5	354.4	583.0	505.0	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		9.81	11.27	17.34	11.27	8.48	8.07	15.32	2.69	7.02	11.43	19.43	16.29
						11.53							

RAINFALL DEPTH (MM) IN YEAR 1985
AT KOLAM AIR TAIPING

DATE	JAN	FEB	MAC	APRIL	MAY	JUNE	JULY	AUG	SEPT	OCT	NOV	DIS	
1	0.0	0.0	15.0	0.0	0.0	26.5	0.0	13.0	0.0	0.0	0.0	0.0	
2	0.0	32.0	30.0	0.0	0.0	21.5	0.0	0.0	15.0	10.5	30.0	0.0	
3	0.0	11.0	37.5	0.0	0.0	40.5	0.0	0.0	0.0	0.0	21.0	26.0	
4	13.0	31.0	12.5	0.0	0.0	9.5	0.0	0.0	0.0	8.0	32.0	15.0	
5	0.0	11.0	10.5	15.0	0.0	0.0	26.0	0.0	0.0	0.0	23.0	0.0	
6	0.0	21.0	6.5	0.0	57.5	0.0	0.0	0.0	0.0	34.0	18.0	0.0	
7	0.0	60.0	13.5	0.0	0.0	0.0	11.5	0.0	0.0	13.0	15.0	27.5	
8	0.0	49.0	0.0	20.0	0.0	0.0	0.0	15.5	0.0	5.0	0.0	0.0	
9	0.0	2.0	25.5	0.0	0.0	0.0	0.0	5.0	45.0	20.5	50.0	6.0	
10	0.0	29.0	33.0	0.0	0.0	0.0	0.0	0.0	5.0	0.0	124.0	21.5	
11	0.0	19.5	15.0	0.0	41.5	0.0	0.0	0.0	21.5	42.0	30.0	0.0	
12	50.0	40.0	0.0	14.0	55.0	0.0	0.0	0.0	20.5	0.0	2.5	4.0	
13	0.0	7.0	13.5	20.0	46.5	0.0	21.0	0.0	10.0	0.0	6.0	5.0	
14	0.0	0.0	0.0	3.0	0.0	0.0	0.0	2.5	8.0	0.0	77.5	17.0	
15	0.0	6.5	0.0	20.0	0.0	0.0	0.0	0.0	3.5	0.0	40.0	4.0	
16	0.0	0.0	0.0	1.0	0.0	0.0	16.0	0.0	0.0	0.0	0.0	3.0	
17	0.0	0.0	0.0	7.5	0.0	0.0	80.0	0.0	0.0	0.0	35.0	0.0	
18	0.0	0.0	100.0	0.0	0.0	0.0	13.0	35.0	0.0	0.0	37.0	0.0	
19	4.0	0.0	7.0	0.0	0.0	0.0	0.0	53.0	11.5	0.0	27.5	0.0	
20	24.5	4.0	3.0	0.0	80.0	0.0	9.0	17.0	0.0	45.0	0.0	0.0	
21	0.0	0.0	2.5	0.0	17.0	0.0	0.0	0.0	0.0	0.0	14.5	0.0	
22	0.0	44.5	2.5	0.0	21.0	0.0	23.5	0.0	0.0	9.5	15.5	0.0	
23	35.0	13.5	9.5	0.0	0.0	0.0	18.5	0.0	29.0	39.5	60.0	0.0	
24	21.0	16.5	10.0	0.0	0.0	0.0	0.0	2.0	0.0	9.0	9.0	0.0	
25	0.0	2.0	0.0	0.0	0.0	0.0	0.0	0.0	48.0	11.0	0.0	0.0	
26	10.0	0.0	26.5	0.0	0.0	0.0	36.5	32.0	120.0	14.5	2.0	0.0	
27	11.0	20.5	13.0	0.0	0.0	0.0	6.0	0.0	2.0	0.0	4.0	0.0	
28	0.0	15.0	47.0	0.0	0.0	0.0	0.0	0.0	24.0	33.0	45.0	0.0	
29	0.0	0.0	28.5	0.0	0.0	0.0	51.0	0.0	0.0	48.5	28.0	0.0	
30	0.0	0.0	3.5	0.0	0.0	0.0	11.0	0.0	35.0	32.0	2.0	25.5	
31	0.0	0.0	0.0	68.0	0.0	0.0	0.0	12.5	0.0	0.2	0.0	0.0	
SUM	168.5	435.0	465.5	168.5	318.5	98.0	323.0	187.5	398.0	375.2	748.5	154.5	
no of days ©		31.00	28.00	31.00	30.00	31.00	30.00	31.00	31.00	30.00	31.00	30.00	31.00
mean (d)		5.44	15.54	15.02	5.62	10.27	3.27	10.42	6.05	13.27	12.10	24.95	4.98
						10.58							

APPENDIX B

CATCHMENT DATA

Nodes	Area		Impervious	Catch. Area (ha)	Length of Overland (m)	Length of Drain (m)	slope %	to (min)	C
				P1					
a10-a14	A1	101	20	7.74	439.14	329.85	1.00	36.00	0.32
a14-a15	A2	102	30	6.35	543.76	281.65	0.50	37.00	0.48
a15-a16	A3	103	20	11.28	496.30	598.09	0.50	47.00	0.43
a16-a17	A4	104	30	9.20	546.13	243.43	2.00	28.00	0.52
a24-a20	A5	105	30	15.00	640.62	411.30	2.00	29.00	0.52
a38-a29	A7	107	20	1.75	90.73	250.14	1.00	15.50	0.50
a29-a21	A10	110	20	1.66	141.00	163.31	1.00	24.00	0.36
a30-a32	A6	106	20	2.99	151.62	215.64	0.50	30.00	0.36
a32-a33	A8	108	20	1.75	100.23	200.00	1.00	20.00	0.45
a33-a34	A9	109	20	1.66	141.00	170.08	1.00	24.00	0.40
c2-c3	C2	302	20	6.90	366.59	230.68	0.50	40.00	0.48
c3-c4	C4	304	30	5.18	319.94	164.03	0.50	30.00	0.52
c4-c5	C6	306	30	6.30	330.57	132.40	1.00	29.00	0.54
c5-c6	C8	308	30	4.71	331.47	151.43	1.00	29.00	0.54
c6-c7	C9	9	30	2.14	211.14	106.66	1.00	23.00	0.56
c7-c8	C10	310	30	2.35	169.87	189.43	1.00	20.00	0.58
c14-c18	C11	311	30	3.10	258.97	236.53	1.00	24.00	0.54
				P2					
b2-b7	B1	201	50	6.39	243.65	618.54	0.20	15.00	0.67
b2-b7	B2	202	50	6.39	275.56	578.08	0.20	16.00	0.66
b12-b26	B3	203	50	1.67	114.64	376.35	0.20	12.00	0.72
b26-b15	B4	20	50	3.94	240.29	214.74	0.20	15.00	0.71
b22-b16	B5	205	50	2.94	148.39	532.81	0.20	13.00	0.71
b16-b18	B6	206	50	5.26	268.50	189.43	0.20	16.00	0.72
b12-b15	B4	204	50	3.94	240.29	299.30	0.20	15.00	0.71
b22-b16	B5	205	50	2.94	148.39	532.81	0.20	13.00	0.71
b16-b18	B6	206	50	5.26	268.50	482.92	0.20	16.00	0.67
d1-d3	D1	401	50	4.39	236.32	565.09	0.20	15.00	0.67
d1-d3	D2	402	50	4.39	180.12	540.79	0.20	14.00	0.69
d0-d4	D3	403	50	12.61	261.02	431.63	0.20	16.00	0.68
d0-d14	D4	404	50	4.39	240.50	389.09	0.20	15.00	0.70
d5-d16	D5	405	50	6.06	265.78	694.80	0.20	15.00	0.66
d17-d6	D6	406	50	6.06	272.04	509.30	0.20	17.00	0.67
d7-d18	D7	407	50	5.24	248.29	509.30	0.20	15.00	0.68
d18-d8	D8	408	50	5.24	276.89	519.00	0.20	17.00	0.66
d9-d21	D9	409	50	8.30	312.47	790.72	0.20	18.00	0.63
d9-d21	D10	410	50	6.94	258.51	684.44	0.20	17.00	0.65
				P3					
c9-c10	C1	301	20	7.31	374.53	231.88	0.50	40.00	0.31
c10-c11	C3	303	30	6.45	369.99	229.45	1.00	28.00	0.54
c11-c12	C5	305	30	6.34	404.20	119.57	1.00	31.00	0.53
c12-c13	C7	307	30	7.64	402.84	140.90	1.00	30.00	0.54
e0-e1	E3	503	20	3.50	242.95	128.25	0.50	35.00	0.52
e1-c13	E4	504	30	4.48	337.36	204.00	0.50	30.00	0.53
e2-e5	E2	502	30	13.72	508.23	408.63	0.50	36.00	0.49
e6-e7	E1	501	30	9.50	385.34	303.30	0.50	32.00	0.52

APPENDIX C

Table 4.2 : Rational Method Runoff Coefficients for Urban Centres

Land Use	Runoff Coefficient
Business : City areas fully built-up and shophouses	0.90
Industrial : Fully built up	0.80
Residential:-	
4 houses/acre	0.55
4-8 houses/acre	0.65
8-12 houses/acre	0.75
12 houses/acre	0.85
Pavement	0.95
Parks (normally flat in urban areas)	0.30
Rubber	0.45
Jungle (normall steep in urban areas)	0.35
Mining land	0.10
Bare earth	0.75

Table 13.3 : Values of F_D for equation design rainfall depth, P_d

Duration	$^2P_{24}h$ (mm)				
	West Coast				East Cost
(minutes)	<100	120	150	>180	All
5	2.08	1.85	1.62	1.40	1.39
10	1.28	1.13	0.99	0.86	1.03
15	0.80	0.72	0.62	0.54	0.74
20	0.47	0.42	0.36	0.32	0.48
25	0.23	0.21	0.18	0.16	0.24
30	0.00	0.00	0.00	0.00	0.00

Table 13.A1 : Coefficients of the IDF Equation for the different major cities and towns in Malaysia (30< t< 1000 min)

State	Location	Data Period	ARI	Coefficient of the IDF Polynomial Equations			
			(years)	a	b	c	d
Perak	Bagan Serai	1960-1983	2	4.1689	0.8160	-0.2726	0.0149
			5	4.7867	0.4919	-0.1993	0.0099
			10	5.2760	0.2436	-0.1436	0.0059
			20	5.6661	0.0329	-0.0944	0.0024
			50	5.3431	0.3538	-0.1686	0.0078
			100	5.3299	0.4357	-0.1857	0.0089

Table 14.2 : Values of Manning's 'n' for Overland Flow

Surface Type	Manning n	
	Recommended	Range
Concrete / Asphlat**	0.011	0.01-0.013
Bare Sand **	0.01	0.01-0.06
Bare Clay-Loam** (eroded)	0.02	0.012-0.033
Gravelled Surface**	0.02	0.012-0.03
Packed Clay**	0.03	0.02-0.04
Short Grass**	0.15	0.10-0.20
Light Turf*	0.20	0.15-0.25
Lawns*	0.25	0.20-0.30
Dense Turf*	0.35	0.30-0.40
Pasture*	0.35	0.30-0.40
Dense Shruberry and Forest Litter*	0.40	0.35-0.50

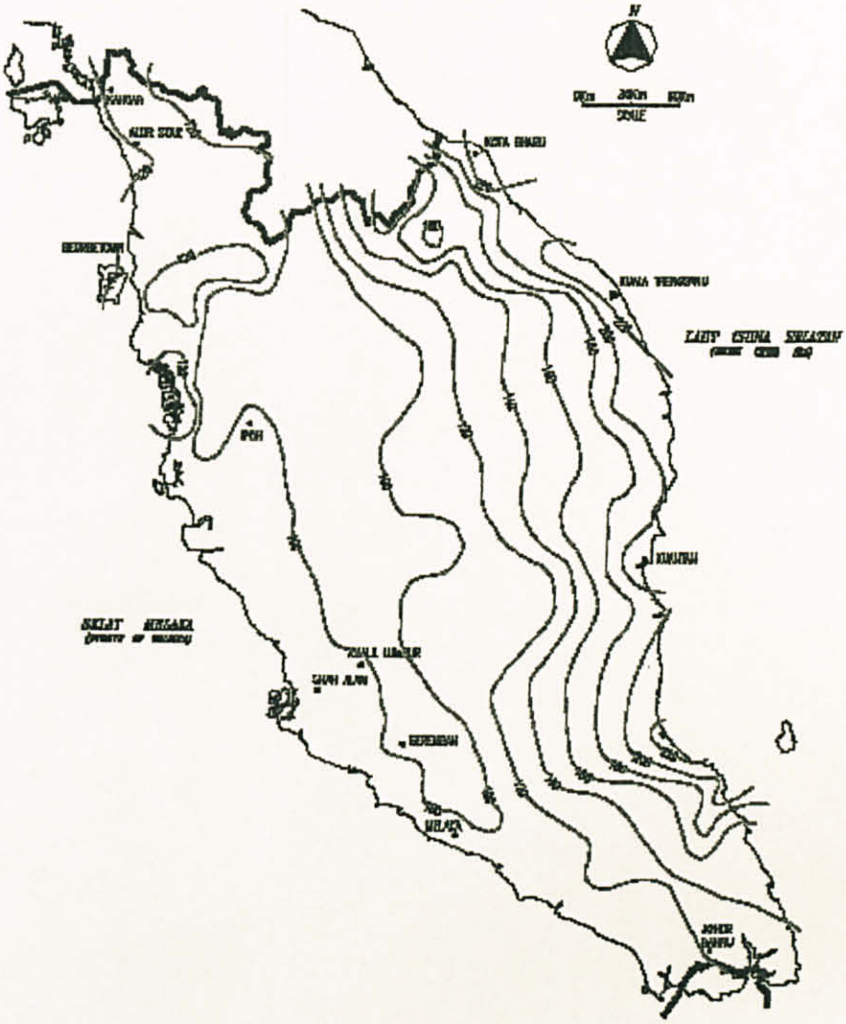


Figure 13.3 Values of $^{2}P_{24h}$ for use with Table 13.3
(source: HP 1, 1982)

7.3 Table for Capacity and Velocity of P.C Block Drain

Capacity and Velocity of 300mm dia. P.C Block Drain and Slope 1:400

300 mm dia. P.C Block Drain + BrickSide $n = 0.015$ $s = 0.150$ m

Height BS	Drain Area			Wetted Perimeter			Hydraulic Radius	Drain Slope	Drain Capacity ,	Drain Velocity
H (m)	A (drain) (m^2)	A (wall) (m^2)	A (total) (m^2)	P (drain) (m)	P (wall) (m)	P (total) (m)	$R^{2/3}$	So $^{1/2}$	$Q = (A \times R^{2/3} \times S^{1/2}) / n$ (m^3/s)	V (m/s)
0	0.060	0.000	0.060	0.710	0.000	0.710	0.193	0.050	0.039	0.64
0.25	0.060	0.150	0.210	0.710	0.800	1.510	0.268	0.050	0.188	0.89
0.50	0.060	0.300	0.360	0.710	1.300	2.010	0.318	0.050	0.381	1.06
0.75	0.060	0.450	0.510	0.710	1.800	2.510	0.346	0.050	0.588	1.15
1.00	0.060	0.600	0.660	0.710	2.300	3.010	0.364	0.050	0.800	1.21
1.25	0.060	0.750	0.810	0.710	2.800	3.510	0.376	0.050	1.016	1.25
1.50	0.060	0.900	0.960	0.710	3.300	4.010	0.386	0.050	1.234	1.29

Capacity and Velocity of 450mm dia. P.C Block Drain and Slope 1:400

450 mm dia. P.C Block Drain + BrickSide $n = 0.015$ $s = 0.150$ m

Height BS	Drain Area			Wetted Perimeter			Hydraulic Radius	Drain Slope	Drain Capacity ,	Drain Velocity
H (m)	A (drain) (m^2)	A (wall) (m^2)	A (total) (m^2)	P (drain) (m)	P (wall) (m)	P (total) (m)	$R^{2/3}$	So $^{1/2}$	$Q = (A \times R^{2/3} \times S^{1/2}) / n$ (m^3/s)	V (m/s)
0	0.138	0.000	0.138	1.068	0.000	1.068	0.256	0.050	0.118	0.85
0.25	0.138	0.188	0.326	1.068	0.800	1.868	0.312	0.050	0.338	1.04
0.50	0.138	0.375	0.513	1.068	1.300	2.368	0.361	0.050	0.617	1.20
0.75	0.138	0.563	0.701	1.068	1.800	2.868	0.391	0.050	0.912	1.30
1.00	0.138	0.750	0.888	1.068	2.300	3.368	0.411	0.050	1.217	1.37
1.25	0.138	0.938	1.076	1.068	2.800	3.868	0.426	0.050	1.527	1.42
1.50	0.138	1.125	1.263	1.068	3.300	4.368	0.437	0.050	1.841	1.46

Capacity and Velocity of 600mm dia. P.C Block Drain and Slope 1:400

600 mm dia. P.C Block Drain + BrickSide $n = 0.015$ $s = 0.150$ m

Height BS	Drain Area			Wetted Perimeter			Hydraulic Radius	Drain Slope	Drain Capacity ,	Drain Velocity
H (m)	A (drain) (m^2)	A (wall) (m^2)	A (total) (m^2)	P (drain) (m)	P (wall) (m)	P (total) (m)	$R^{2/3}$	So $^{1/2}$	$Q = (A \times R^{2/3} \times S^{1/2}) / n$ (m^3/s)	V (m/s)
0	0.241	0.000	0.241	1.418	0.000	1.418	0.307	0.050	0.246	1.02
0.25	0.241	0.225	0.466	1.418	0.800	2.218	0.353	0.050	0.549	1.18
0.50	0.241	0.450	0.691	1.418	1.300	2.718	0.401	0.050	0.924	1.34
0.75	0.241	0.675	0.916	1.418	1.800	3.218	0.433	0.050	1.321	1.44
1.00	0.241	0.900	1.141	1.418	2.300	3.718	0.455	0.050	1.730	1.52
1.25	0.241	1.125	1.366	1.418	2.800	4.218	0.472	0.050	2.147	1.57
1.50	0.241	1.350	1.591	1.418	3.300	4.718	0.484	0.050	2.569	1.61

Capacity and Velocity of 900mm dia. P.C Block Drain and Slope 1:200

900 mm dia. P.C Block Drain + BrickSide $n = 0.015$ $s = 0.250$ m

Height BS	Drain Area			Wetted Perimeter			Hydraulic Radius	Drain Slope	Drain Capacity ,	Drain Velocity
H (m)	A (drain) (m^2)	A (wall) (m^2)	A (total) (m^2)	P (drain) (m)	P (wall) (m)	P (total) (m)	$R^{2/3}$	So $^{1/2}$	$Q = (A \times R^{2/3} \times S^{1/2}) / n$ (m^3/s)	V (m/s)
0	0.612	0.000	0.612	2.155	0.500	2.655	0.376	0.071	1.085	1.77
0.25	0.612	0.350	0.962	2.155	1.000	3.155	0.453	0.071	2.054	2.14
0.50	0.612	0.700	1.312	2.155	1.500	3.655	0.505	0.071	3.124	2.38
0.75	0.612	1.050	1.662	2.155	2.000	4.155	0.543	0.071	4.253	2.56
1.00	0.612	1.400	2.012	2.155	2.500	4.655	0.572	0.071	5.422	2.69
1.25	0.612	1.750	2.362	2.155	3.000	5.155	0.594	0.071	6.618	2.80
1.50	0.612	2.100	2.712	2.155	3.500	5.655	0.613	0.071	7.833	2.89

APPENDIX

P1 POND INLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Fd	tc = 30 min (10-yr ARI) a 5.2760 a	b 0.2436 b ln(30)	c -0.1436 $c \ln(30)^2$	d 0.0059 $d \ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	P_{30} (mm)	tc = 60 min (10-yr ARI) a 5.2760	b 0.2436 b ln(60)	c -0.1436 $c \ln(60)^2$	d 0.0059 $d \ln(60)^3$	ln(I)	$^{10}I_{60}$ (mm/hr)	P_{60} (mm)	P_5	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drai[n] Veloci[ty] (m/s)
A1	a10-a14	7.74	439.14	36.00	329.85	106.20	3.11	39.11	-	5.2760	0.8931	-1.9567	0.2908	4.5031	90.30	-	-	-	-	-	-	-	-	-	90.30	0.32	**0.621**	**0.621**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A2	a14-a15	6.35	543.76	37.00	281.65	128.40	2.19	39.19	-	5.2760	0.8936	-1.9654	0.2913	4.4955	89.61	-	-	-	-	-	-	-	-	-	89.61	0.48	**0.759**	**1.380**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
A3	a15-a16	11.28	496.30	47.00	598.09	153.60	3.89	50.89	-	5.2760	0.9573	-2.2176	0.3581	4.3737	79.34	-	-	-	-	-	-	-	-	-	79.34	0.43	**1.069**	**2.449**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
A4	a16-a17	9.20	546.13	28.00	243.43	153.60	1.58	29.58	-	5.2760	0.8251	-1.6476	0.2293	4.6828	108.08	-	-	-	-	-	-	-	-	-	108.08	0.52	**1.436**	**3.885**	902 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
A5	a24-a20	15.00	640.62	29.00	411.30	142.80	2.88	31.88	-	5.2760	0.8433	-1.7211	0.2448	4.6431	103.86	-	-	-	-	-	-	-	-	-	103.86	0.52	**2.250**	**2.250**	900 mm dia. + 0.5m BS	1:400	**3.124**	**2.38**
A7	a38-a29	1.75	90.73	15.50	250.14	106.20	2.36	17.86	0.45	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	45.56	153.10	0.50	**0.372**	**0.372**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A10	a29-a21	1.66	141.00	33.00	163.31	106.20	1.54	35.00	-	5.2760	0.8661	-1.8152	0.2652	4.5921	98.70	-	-	-	-	-	-	-	-	-	98.70	0.36	**0.164**	**0.164**	900 mm dia. + 0.0m BS	1:400	**1.085**	**1.77**
A6	a30-a32	2.99	151.62	30.00	215.64	106.20	2.03	32.03	-	5.2760	0.8445	-1.7258	0.2458	4.6405	103.60	-	-	-	-	-	-	-	-	-	103.60	0.36	**0.310**	**0.310**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A8	a32-a33	1.75	100.23	20.00	200.00	106.20	1.88	21.88	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	126.89	0.45	**0.278**	**0.587**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A9	a33-a34	1.66	141.00	24.00	170.08	128.40	1.32	25.32	0.39	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.64	110.5	0.40	**0.204**	**0.791**	900 mm dia. + 0.25m BS	1:400	**1.085**	**1.77**
C2	c2-c3	6.90	366.59	40.00	230.68	106.20	2.17	42.17	-	5.2760	0.9115	-2.0105	0.3091	4.4861	88.77	-	-	-	-	-	-	-	-	-	88.77	0.48	**0.817**	**0.817**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
C4	c3-c4	5.18	319.94	30.00	164.03	128.40	1.28	31.28	-	5.2760	0.8387	-1.7022	0.2408	4.6533	104.93	-	-	-	-	-	-	-	-	-	104.93	0.52	**0.785**	**1.602**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
C6	c4-c5	6.30	330.57	29.00	132.40	128.40	1.03	30.03	-	5.2760	0.8288	-1.6622	0.2324	4.6749	107.23	-	-	-	-	-	-	-	-	-	107.23	0.54	**1.013**	**2.615**	900 mm dia. + 0.25m BS	1:400	**3.120**	**2.38**
C8	c5-c6	4.71	331.47	29.00	151.43	153.60	0.99	29.99	-	5.2760	0.8284	-1.6607	0.2320	4.6757	107.31	-	-	-	-	-	-	-	-	-	107.31	0.54	**0.758**	**3.373**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.38**
C9	c6-c7	2.14	211.14	23.00	106.66	153.60	0.69	23.69	0.40	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.46	117.65	0.56	**0.392**	**3.765**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
C10	c7-c8	2.35	169.87	20.00	189.43	161.40	1.17	21.17	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	131.14	0.58	**0.497**	**4.261**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.69**
C11	c14-c18	3.10	258.97	24.00	236.53	106.20	2.23	26.23	0.39	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.64	106.7	0.54	**0.496**	**0.496**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**

P2 POND INLET

RETURN PERIOD 10 ARI

										tc = 30 min (10-yr ARI)							tc = 60 min (10-yr ARI)															
Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Fd	a 5.2760 a	b 0.2436 b ln(30)	c -0.1436 c $\ln(30)^2$	d 0.0059 d $\ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	P_{30} (mm)	a 5.2760	b 0.2436 b ln(60)	c -0.1436 c $\ln(60)^2$	d 0.0059 d $\ln(60)^3$	ln(I)	$^{10}I_{60}$ (mm/hr)	P_{60} (mm)	P_5	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
B1	b2-b7	6.39	243.65	15.00	618.54	128.40	4.82	19.82	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	140.12	0.67	**1.666**	**1.666**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B2	b2-b7	6.39	275.56	16.00	578.08	128.40	4.50	20.50	0.42	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.10	134.91	0.66	**1.581**	**1.581**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B3	b12-b26	1.67	114.64	12.00	376.35	106.20	3.54	15.54	0.70	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	41.07	158.54	0.72	**0.530**	**0.530**	900 mm dia. + 0m BS	1:400	**1.085**	**1.77**
B4	b26-b15	3.94	240.29	15.00	214.74	128.40	1.67	16.67	0.65	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	41.97	151.04	0.71	**1.174**	**1.703**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B5	b22-b16	2.94	148.39	13.00	532.81	142.80	3.73	16.73	0.42	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.10	165.32	0.71	**0.959**	**2.662**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
B6	b16-b18	5.26	268.50	16.00	189.43	153.60	1.23	17.23	0.50	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	44.66	155.5	0.72	**1.636**	**4.298**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
B4	b12-b15	3.94	240.29	15.00	299.30	128.40	2.33	17.33	0.50	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	44.66	154.63	0.71	**1.202**	**1.202**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B5	b22-b16	2.94	148.39	13.00	532.81	128.40	4.15	17.15	0.42	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.10	161.29	0.71	**0.935**	**0.935**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B6	b16-b18	5.26	268.50	16.00	482.92	128.40	3.76	19.76	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	140.52	0.67	**1.376**	**1.376**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D1	d1-d3	4.39	236.32	15.00	565.09	128.40	4.40	19.40	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	143.13	0.67	**1.169**	**1.169**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D2	d1-d3	4.39	180.12	14.00	540.79	128.40	4.21	18.21	0.42	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.10	151.88	0.69	**1.278**	**1.278**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D3	d0-d4	5.10	261.02	16.00	431.63	128.40	3.36	19.36	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	143.42	0.68	**1.382**	**1.382**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D4	d0-d14	4.39	240.50	15.00	389.09	128.40	3.03	18.03	0.42	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.10	153.41	0.70	**1.310**	**1.310**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D5	d5-d16	6.06	265.78	15.00	694.80	128.40	5.41	20.41	0.38	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.82	137.63	0.66	**1.529**	**1.529**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D6	d17-d6	6.06	272.04	17.00	509.30	128.40	3.97	20.97	0.38	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.82	133.98	0.67	**1.511**	**1.511**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D7	d7-d18	5.24	248.29	15.00	509.30	128.40	3.97	18.97	0.41	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.28	146.41	0.68	**1.449**	**1.449**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D8	d18-d8	5.24	276.89	17.00	519.00	128.40	4.04	21.04	0.38	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	46.82	133.5	0.66	**1.282**	**1.282**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D9	d9-d21	8.30	312.47	18.00	790.72	128.40	6.16	24.16	0.20	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	50.05	124.31	0.63	**1.806**	**1.806**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D10	d9-d21	6.94	258.51	17.00	684.44	128.40	5.33	22.33	0.26	5.2760	0.8285	-1.6612	0.2321	4.6755	107.28	53.64	5.2760	0.9974	-2.4073	0.4050	4.2711	71.60	71.60	48.97	131.59	0.65	**1.649**	**1.649**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**

P3 POND INLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	tc = 30 min (10-yr ARI) a 5.2760 a	b 0.2436 b ln(30)	c -0.1436 c $\ln(30)^2$	d 0.0059 d $\ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
C1	c9-c10	7.31	374.53	40.00	231.88	106.20	2.18	42.18	5.2760	0.9116	-2.0108	0.3092	4.4859	88.76	88.76	0.31	**0.559**	**0.559**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
C3	c10-c11	6.45	369.99	28.00	229.45	128.40	1.79	29.79	5.2760	0.8268	-1.6542	0.2307	4.6792	107.69	107.69	0.54	**1.042**	**1.601**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
C5	c11-c12	6.34	404.20	31.00	119.57	142.80	0.84	31.84	5.2760	0.8430	-1.7198	0.2445	4.6438	103.94	103.94	0.53	**0.970**	**2.571**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
C7	c12-c13	7.64	402.84	30.00	140.90	153.60	0.92	30.92	5.2760	0.8359	-1.6907	0.2384	4.6595	105.58	105.58	0.54	**1.210**	**3.781**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
E3	e0-e1	3.50	242.95	35.00	128.25	106.20	1.21	36.21	5.2760	0.8743	-1.8500	0.2728	4.5732	96.85	96.85	0.52	**0.490**	**0.490**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
E4	e1-c13	4.48	337.36	30.00	204.00	128.40	1.59	31.59	5.2760	0.8411	-1.7120	0.2429	4.6480	104.38	104.38	0.53	**0.688**	**1.178**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**

P3 POND OUTLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	tc = 30 min (10-yr ARI) a 5.2760 a	b 0.2436 b ln(30)	c -0.1436 c $\ln(30)^2$	d 0.0059 d $\ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
E2	e2-e5	13.72	508.23	36.00	408.63	128.40	3.18	39.18	5.2760	0.8936	-1.9323	0.2912	4.5285	92.62	92.62	0.49	**1.730**	**1.730**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
E1	e6-e7	9.50	385.34	32.00	303.30	142.80	2.12	34.12	5.2760	0.8599	-1.7894	0.2595	4.6060	100.09	100.09	0.52	**1.373**	**3.103**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**

APPENDIX

P1 POND INLET

RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Fd	tc = 30 min (50-yr ARI) a 5.3431 a	b 0.3538 b ln(30)	c -0.1686 $c \ln(30)^2$	d 0.0078 $d \ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	P_{30} (mm)	tc = 60 min (50-yr ARI) a 5.3431	b 0.3538 b ln(60)	c -0.1686 $c \ln(60)^2$	d 0.0078 $d \ln(60)^3$	ln(I)	$^{10}I_{60}$ (mm/hr)	P_{60} (mm)	P_5	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
A1	a10-a14	7.74	439.14	36.00	329.85	106.20	3.11	39.11	-	5.3431	1.2971	-2.2974	0.3844	4.7272	112.98	-	-	-	-	-	-	-	-	-	112.98	0.32	0.777	0.777	900 mm dia. + 0m BS	1:400	1.085	1.77
A2	a14-a15	6.35	543.76	37.00	281.65	128.40	2.19	39.19	-	5.3431	1.2979	-2.3076	0.3851	4.7185	112.00	-	-	-	-	-	-	-	-	-	112.00	0.48	0.948	1.726	900 mm dia. + 0.25m BS	1:400	2.054	2.14
A3	a15-a16	11.28	496.30	47.00	598.09	153.60	3.89	50.89	-	5.3431	1.3903	-2.6037	0.4734	4.6031	99.80	-	-	-	-	-	-	-	-	-	99.80	0.43	1.345	3.070	900 mm dia. + 0.75m BS	1:400	4.253	2.56
A4	a16-a17	9.20	546.13	28.00	243.43	161.40	1.51	29.51	-	5.3431	1.1975	-1.9315	0.3024	4.9116	135.85	-	-	-	-	-	-	-	-	-	135.85	0.52	1.805	4.875	902 mm dia. + 1.00m BS	1:400	5.422	2.69
A5	a24-a20	15.00	640.62	29.00	411.30	142.80	2.88	31.88	-	5.3431	1.2249	-2.0207	0.3236	4.8709	130.43	-	-	-	-	-	-	-	-	-	130.43	0.52	2.826	2.826	900 mm dia. + 0.50m BS	1:400	3.124	2.38
A7	a38-a29	1.75	90.73	15.50	250.14	106.20	2.36	17.86	0.45	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	57.11	191.92	0.50	0.466	0.466	900 mm dia. + 0.00m BS	1:400	1.085	1.77
A10	a29-a21	1.66	141.00	33.00	163.31	128.40	1.27	35.00	-	5.3431	1.2579	-2.1312	0.3505	4.8203	124.01	-	-	-	-	-	-	-	-	-	124.01	0.36	0.206	0.206	900 mm dia. + 0.25m BS	1:400	2.054	2.14
A6	a30-a32	2.99	151.62	30.00	215.64	106.20	2.03	32.03	-	5.3431	1.2265	-2.0262	0.3250	4.8684	130.11	-	-	-	-	-	-	-	-	-	130.11	0.36	0.389	0.389	900 mm dia. + 0.00m BS	1:400	1.085	1.77
A8	a32-a33	1.75	100.23	20.00	200.00	106.20	1.88	21.88	0.41	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	58.02	159.08	0.45	0.348	0.737	900 mm dia. + 0.00m BS	1:400	1.085	1.77
A9	a33-a34	1.66	141.00	24.00	170.08	106.20	1.60	25.60	0.39	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	58.48	137.05	0.40	0.253	0.990	900 mm dia. + 0.25m BS	1:400	1.085	1.77
C2	c2-c3	6.90	366.59	40.00	230.68	106.20	2.17	42.17	-	5.3431	1.3238	-2.3605	0.4086	4.7150	111.61	-	-	-	-	-	-	-	-	-	111.61	0.48	1.027	1.027	900 mm dia. + 0.00m BS	1:400	1.085	1.77
C4	c3-c4	5.18	319.94	30.00	164.03	128.40	1.28	31.28	-	5.3431	1.2181	-1.9985	0.3183	4.8810	131.76	-	-	-	-	-	-	-	-	-	131.76	0.52	0.986	2.013	900 mm dia. + 0.25m BS	1:400	2.054	2.14
C6	c4-c5	6.30	330.57	29.00	132.40	153.60	0.86	29.86	-	5.3431	1.2017	-1.9451	0.3056	4.9054	135.01	-	-	-	-	-	-	-	-	-	135.01	0.54	1.276	3.289	900 mm dia. + 0.75m BS	1:400	4.253	2.38
C8	c5-c6	4.71	331.47	29.00	151.43	153.60	0.99	29.99	-	5.3431	1.2032	-1.9498	0.3068	4.9032	134.72	-	-	-	-	-	-	-	-	-	134.72	0.54	0.952	4.240	900 mm dia. + 0.75m BS	1:400	4.253	2.38
C9	c6-c7	2.14	211.14	23.00	106.66	161.40	0.66	23.66	0.40	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	58.25	147.71	0.56	0.492	4.732	900 mm dia. + 1.00m BS	1:400	5.422	2.69
C10	c7-c8	2.35	169.87	20.00	189.43	161.40	1.17	21.17	0.41	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	58.02	164.42	0.58	0.622	5.355	900 mm dia. + 1.00m BS	1:400	5.422	2.69
C11	c14-c18	3.10	258.97	24.00	236.53	106.20	2.23	26.23	0.39	5.3431	1.2033	-1.9504	0.3069	4.9029	134.69	67.34	5.3431	1.4486	-2.8264	0.5354	4.5007	90.08	90.08	58.48	133.78	0.54	0.622	0.622	900 mm dia. + 0.25m BS	1:400	1.085	1.77

P3 POND INLET

RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	tc = 30 min (50-yr ARI)						$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
									a 5.3431	b 0.3538	c -0.1686	d 0.0078	ln(I)	$^{10}I_{30}$ (mm/hr)								
									a	b ln(30)	c $\ln(30)^2$	d $\ln(30)^3$										
C1	c9-c10	7.31	374.53	40.00	231.88	106.20	2.18	42.18	5.3431	1.3239	-2.3609	0.4087	4.7149	111.59	111.59	0.34	**0.702**	**0.702**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
C3	c10-c11	6.45	369.99	28.00	229.45	128.40	1.79	29.79	5.3431	1.2008	-1.9422	0.3050	4.9067	135.19	135.19	0.54	**1.308**	**2.010**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
C5	c11-c12	6.34	404.20	31.00	119.57	153.60	0.78	31.78	5.3431	1.2237	-2.0170	0.3228	4.8726	130.66	130.66	0.53	**1.220**	**3.230**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
C7	c12-c13	7.64	402.84	30.00	140.90	161.40	0.87	30.87	5.3431	1.2135	-1.9834	0.3147	4.8879	132.67	132.67	0.54	**1.520**	**4.750**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.69**
E3	e0-e1	3.50	242.95	35.00	128.25	106.20	1.21	36.21	5.3431	1.2699	-2.1720	0.3607	4.8016	121.71	121.71	0.52	**0.615**	**0.615**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
E4	e1-c13	4.48	337.36	30.00	204.00	128.40	1.59	31.59	5.3431	1.2216	-2.0100	0.3211	4.8758	131.07	131.07	0.53	**0.865**	**1.480**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**

P3 POND OUTLET

RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	tc = 30 min (50-yr ARI) a	b	c	d	ln(I)	$^{10}I_{30}$ (mm/hr)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
									5.3431	0.3538	-0.1686	0.0078										
									a	b ln(30)	c $\ln(30)^2$	d $\ln(30)^3$										
E2	e2-e5	13.72	508.23	36.00	408.63	142.80	2.86	38.86	5.3431	1.2949	-2.2585	0.3824	4.7619	116.97	116.97	0.49	**2.184**	**2.184**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
E1	e6-e7	9.50	385.34	32.00	303.30	153.60	1.97	33.97	5.3431	1.2474	-2.0957	0.3418	4.8366	126.04	126.04	0.52	**1.730**	**3.914**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**

APPENDIX

P1 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Fd	tc = 30 min (100-yr ARI)							tc = 60 min (100-yr ARI)							P_5	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
										a 5.3299 a	b 0.4357 b ln(30)	c -0.1857 c $\ln(30)^2$	d 0.0089 d $\ln(30)^3$	ln(I)	$^{10}I_{30}$ (mm/hr)	P_{30} (mm)	a 5.3299	b 0.4357 b ln(60)	c -0.1857 c $\ln(60)^2$	d 0.0089 d $\ln(60)^3$	ln(I)	$^{10}I_{60}$ (mm/hr)	P_{60} (mm)									
A1	a10-a14	7.74	439.14	36.00	329.85	106.20	3.11	39.11	-	5.3299	1.5974	-2.5304	0.4386	4.8355	125.90	-	-	-	-	-	-	-	-	-	125.90	0.32	**0.866**	**0.866**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A2	a14-a15	6.35	543.76	37.00	281.65	128.40	2.19	39.19	-	5.3299	1.5984	-2.5416	0.4394	4.8260	124.71	-	-	-	-	-	-	-	-	-	124.71	0.48	**1.056**	**1.922**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
A3	a15-a16	11.28	496.30	47.00	598.09	153.60	3.89	50.89	-	5.3299	1.7122	-2.8677	0.5401	4.7145	111.55	-	-	-	-	-	-	-	-	-	111.55	0.43	**1.503**	**3.425**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
A4	a16-a17	9.20	546.13	28.00	243.43	168.00	1.45	29.45	-	5.3299	1.4738	-2.1249	0.3445	5.0234	151.92	-	-	-	-	-	-	-	-	-	151.92	0.52	**2.019**	**5.444**	902 mm dia. + 1.25m BS	1:400	**6.618**	**2.80**
A5	a24-a20	15.00	640.62	29.00	411.30	153.60	2.68	31.68	-	5.3299	1.5056	-2.2175	0.3673	4.9853	146.24	-	-	-	-	-	-	-	-	-	146.24	0.52	**3.169**	**3.169**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
A7	a38-a29	1.75	90.73	15.50	250.14	106.20	2.36	17.86	0.45	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	63.80	214.39	0.50	**0.521**	**0.521**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
A10	a29-a21	1.66	141.00	33.00	163.31	128.40	1.27	35.00	-	5.3299	1.5491	-2.3473	0.4000	4.9316	138.60	-	-	-	-	-	-	-	-	-	138.60	0.36	**0.230**	**0.230**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
A6	a30-a32	2.99	151.62	30.00	215.64	106.20	2.03	32.03	-	5.3299	1.5104	-2.2317	0.3708	4.9794	145.39	-	-	-	-	-	-	-	-	-	145.39	0.36	**0.435**	**0.435**	900 mm dia. + 0m BS	1:400	**1.085**	**1.77**
A8	a32-a33	1.75	100.23	20.00	200.00	106.20	1.88	21.88	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	177.71	0.45	**0.389**	**0.823**	900 mm dia. + 0m BS	1:400	**1.085**	**1.77**
A9	a33-a34	1.66	141.00	24.00	170.08	128.40	1.32	25.32	0.39	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.32	154.77	0.40	**0.285**	**1.109**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
C2	c2-c3	6.90	366.59	40.00	230.68	128.40	1.80	41.80	-	5.3299	1.6264	-2.5875	0.4629	4.8317	125.42	-	-	-	-	-	-	-	-	-	125.42	0.48	**1.154**	**1.154**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
C4	c3-c4	5.18	319.94	30.00	164.03	142.80	1.15	31.15	-	5.3299	1.4983	-2.1959	0.3619	4.9942	147.55	-	-	-	-	-	-	-	-	-	147.55	0.52	**1.104**	**2.258**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
C6	c4-c5	6.30	330.57	29.00	132.40	153.60	0.86	29.86	-	5.3299	1.4799	-2.1424	0.3488	5.0162	150.83	-	-	-	-	-	-	-	-	-	150.83	0.54	**1.425**	**3.683**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
C8	c5-c6	4.71	331.47	29.00	151.43	161.40	0.94	29.94	-	5.3299	1.4810	-2.1456	0.3495	5.0148	150.63	-	-	-	-	-	-	-	-	-	150.63	0.54	**1.064**	**4.747**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.69**
C9	c6-c7	2.14	211.14	23.00	106.66	161.40	0.66	23.66	0.40	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.07	165.01	0.56	**0.549**	**5.297**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.69**
C10	c7-c8	2.35	169.87	20.00	189.43	168.00	1.13	21.13	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	184.07	0.58	**0.697**	**5.994**	900 mm dia. + 1.25m BS	1:400	**6.618**	**2.80**
C11	c14-c18	3.10	258.97	24.00	236.53	128.40	1.84	25.84	0.39	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.32	151.67	0.54	**0.705**	**0.705**	900 mm dia. + 0.25m BS	1:400	**1.085**	**1.77**

P2 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	Fd	tc = 30 min (100-yr ARI) a 5.3299 a	b 0.4357 b ln(30)	c -0.1857 c ln(30)^2	d 0.0089 d ln(30)^3	ln(I)	$^{10}I_{30}$ (mm/hr)	P_{30} (mm)	tc = 60 min (100-yr ARI) a 5.3299	b 0.4357 b ln(60)	c -0.1857 c ln(60)^2	d 0.0089 d ln(60)^3	ln(I)	$^{10}I_{60}$ (mm/hr)	P_{60} (mm)	P_5	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
B1	b2-b7	6.39	243.65	15.00	618.54	142.80	4.33	19.33	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	201.17	0.67	**2.392**	**2.392**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
B2	b2-b7	6.39	275.56	16.00	578.08	128.40	4.50	20.50	0.42	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.56	188.94	0.66	**2.213**	**2.213**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B3	b12-b26	1.67	114.64	12.00	376.35	106.20	3.54	15.54	0.70	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	57.45	221.74	0.72	**0.741**	**0.741**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
B4	b26-b15	3.94	240.29	15.00	214.74	142.80	1.50	16.50	0.65	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	58.72	213.46	0.71	**1.659**	**2.399**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
B5	b22-b16	2.94	148.39	13.00	532.81	153.60	3.47	16.47	0.42	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.56	235.21	0.71	**1.364**	**3.763**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
B6	b16-b18	5.26	268.50	16.00	189.43	168.00	1.13	17.13	0.50	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	62.53	219.04	0.72	**2.304**	**6.068**	900 mm dia. + 1.25m BS	1:400	**6.618**	**2.80**
B4	b12-b15	3.94	240.29	15.00	299.30	128.40	2.33	17.33	0.50	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	62.53	216.47	0.71	**1.682**	**1.682**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B5	b22-b16	2.94	148.39	13.00	532.81	128.40	4.15	17.15	0.42	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.56	225.88	0.71	**1.310**	**1.310**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
B6	b16-b18	5.26	268.50	16.00	482.92	128.40	3.76	19.76	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	196.8	0.67	**1.927**	**1.927**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D1	d1-d3	4.39	236.32	15.00	565.09	128.40	4.40	19.40	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	200.45	0.67	**1.638**	**1.638**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D2	d1-d3	4.39	180.12	14.00	540.79	128.40	4.21	18.21	0.42	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.56	212.7	0.69	**1.790**	**1.790**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D3	d0-d4	5.10	261.02	16.00	431.63	128.40	3.36	19.36	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	200.86	0.68	**1.935**	**1.935**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D4	d0-d14	4.39	240.50	15.00	389.09	128.40	3.03	18.03	0.42	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.56	214.84	0.70	**1.834**	**1.834**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D5	d5-d16	6.06	265.78	15.00	694.80	142.80	4.87	19.87	0.38	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.58	198.07	0.66	**2.201**	**2.201**	900 mm dia. + 0.25m BS	1:400	**3.124**	**2.38**
D6	d17-d6	6.06	272.04	17.00	509.30	142.80	3.57	20.57	0.38	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.58	191.31	0.67	**2.158**	**2.158**	900 mm dia. + 0.25m BS	1:400	**3.124**	**2.38**
D7	d7-d18	5.24	248.29	15.00	509.30	128.40	3.97	18.97	0.41	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	64.82	205.04	0.68	**2.029**	**2.029**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D8	d18-d8	5.24	276.89	17.00	519.00	128.40	4.04	21.04	0.38	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	65.58	186.99	0.66	**1.796**	**1.796**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**
D9	d9-d21	8.30	312.47	18.00	790.72	142.80	5.54	23.54	0.20	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	70.15	178.83	0.63	**2.598**	**2.598**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
D10	d9-d21	6.94	258.51	17.00	684.44	142.80	4.79	21.79	0.26	5.3299	1.4819	-2.1482	0.3502	5.0138	150.47	75.24	5.3299	1.7839	-3.1130	0.6109	4.6117	100.65	100.65	68.63	188.94	0.65	**2.368**	**2.368**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**

P3 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	Length of Overland (m)	to (min)	Length of Drain (m)	v (m/min)	td	tc (min)	tc = 30 min (100-yr ARI)						$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)	Drain Size (P.C Block + BS)	Design Slope	Drain Capacity (m^3/s)	Drain Velocity (m/s)
									a	b	c	d	ln(I)	$^{10}I_{30}$ (mm/hr)								
									5.3299	0.4357	-0.1857	0.0089										
									a	b ln(30)	c $\ln(30)^2$	d $\ln(30)^3$										
C1	c9-c10	7.31	374.53	40.00	231.88	106.20	2.18	42.18	5.3299	1.6304	-2.6003	0.4663	4.8263	124.75	124.75	0.31	**0.785**	**0.785**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
C3	c10-c11	6.45	369.99	28.00	229.45	142.80	1.61	29.61	5.3299	1.4762	-2.1316	0.3461	5.0206	151.50	151.50	0.54	**1.466**	**2.251**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
C5	c11-c12	6.34	404.20	31.00	119.57	153.60	0.78	31.78	5.3299	1.5070	-2.2216	0.3683	4.9836	146.00	146.00	0.53	**1.363**	**3.614**	900 mm dia. + 0.75m BS	1:400	**4.253**	**2.56**
C7	c12-c13	7.64	402.84	30.00	140.90	161.40	0.87	30.87	5.3299	1.4944	-2.1846	0.3591	4.9988	148.24	148.24	0.54	**1.699**	**5.313**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.69**
E3	e0-e1	3.50	242.95	35.00	128.25	106.20	1.21	36.21	5.3299	1.5638	-2.3923	0.4115	4.9129	136.04	136.04	0.52	**0.688**	**0.688**	900 mm dia. + 0.00m BS	1:400	**1.085**	**1.77**
E4	e1-c13	4.48	337.36	30.00	204.00	128.40	1.59	31.59	5.3299	1.5044	-2.2139	0.3664	4.9868	146.46	146.46	0.53	**0.966**	**1.654**	900 mm dia. + 0.25m BS	1:400	**2.054**	**2.14**

P3 POND OUTLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area	Length of Overland	to	Length of Drain	v	td	tc	tc = 30 min (100-yr ARI)						$^{10}I_{tc}$	C	Q	Q link	Drain Size	Design Slope	Drain Capacity	Drain Velocity
									a	b	c	d	ln(I)	$^{10}I_{30}$								
									5.3299	0.4357	-0.1857	0.0089										
									a	b ln(30)	c $\ln(30)^2$	d $\ln(30)^3$							(P.C Block + BS)			
		(ha)	(m)	(min)	(m)	(m/min)		(min)						(mm/hr)			(m^3/s)	(m^3/s)			(m^3/s)	(m/s)
E2	e2-e5	13.72	508.23	36.00	408.63	142.80	2.86	38.86	5.3299	1.5947	-2.4876	0.4364	4.8733	130.76	130.76	0.49	**2.442**	**2.442**	900 mm dia. + 0.50m BS	1:400	**3.124**	**2.38**
E1	e6-e7	9.50	385.34	32.00	303.30	161.40	1.88	33.88	5.3299	1.5349	-2.3046	0.3891	4.9493	141.08	141.08	0.52	**1.936**	**4.378**	900 mm dia. + 1.00m BS	1:400	**5.422**	**2.58**

			Qpeaks			
"1	Mass Curve	0.000	0.000	0.000	0.000	"
"2	Catchment 101	1.092	0.000	0.000	0.000	"
"3	Add Runoff	1.092	1.092	0.000	0.000	"
"4	Channel Design	1.092	1.092	0.000	0.000	"
"5	Channel Route 330	1.092	1.092	1.011	0.000	"
"6	Next link	1.092	1.011	1.011	0.000	"
"7	Catchment 102	0.938	1.011	1.011	0.000	"
"8	Add Runoff	0.938	1.861	1.011	0.000	"
"9	Channel Design	0.938	1.861	1.011	0.000	"
"10	Channel Route 282	0.938	1.861	1.820	0.000	"
"11	Next link	0.938	1.820	1.820	0.000	"
"12	Catchment 103	1.400	1.820	1.820	0.000	"
"13	Add Runoff	1.400	3.034	1.820	0.000	"
"14	Channel Design	1.400	3.034	1.820	0.000	"
"15	Channel Route 598	1.400	3.034	2.866	0.000	"
"16	Next link	1.400	2.866	2.866	0.000	"
"17	Catchment 104	1.578	2.866	2.866	0.000	"
"18	Add Runoff	1.578	3.910	2.866	0.000	"
"19	Channel Design	1.578	3.910	2.866	0.000	"
"20	Channel Route 243	1.578	3.910	3.851	0.000	"
"21	Combine 110	1.578	3.910	3.851	3.851	"
"22	Combine 110	1.578	3.910	3.851	3.851	"
"23	Start - New Tributary	1.578	0.000	3.851	3.851	"
"24	Catchment 105	2.496	0.000	3.851	3.851	"
"25	Add Runoff	2.496	2.496	3.851	3.851	"
"26	Channel Design	2.496	2.496	3.851	3.851	"
"27	Channel Route 411	2.496	2.496	2.368	3.851	"
"28	Combine 110	2.496	2.496	2.368	5.961	"
"29	Start - New Tributary	2.496	0.000	2.368	5.961	"
"30	Catchment 107	0.360	0.000	2.368	5.961	"
"31	Add Runoff	0.360	0.360	2.368	5.961	"
"32	Channel Design	0.360	0.360	2.368	5.961	"
"33	Channel Route 250	0.360	0.360	0.345	5.961	"
"34	Combine 110	0.360	0.360	0.345	6.289	"
"35	Confluence 110	0.360	6.289	0.345	0.000	"
"36	Catchment 110	0.302	6.289	0.345	0.000	"
"37	Add Runoff	0.302	6.524	0.345	0.000	"
"38	Channel Design	0.302	6.524	0.345	0.000	"
"39	Channel Route 163	0.302	6.524	6.311	0.000	"
"40	Combine 1	0.302	6.524	6.311	6.311	"
"41	Start - New Tributary	0.302	0.000	6.311	6.311	"
"42	Catchment 311	0.581	0.000	6.311	6.311	"
"43	Add Runoff	0.581	0.581	6.311	6.311	"
"44	Channel Design	0.581	0.581	6.311	6.311	"
"45	Channel Route 237	0.581	0.581	0.566	6.311	"
"46	Combine 1	0.581	0.581	0.566	6.814	"
"47	Start - New Tributary	0.581	0.000	0.566	6.814	"
"48	Catchment 106	0.498	0.000	0.566	6.814	"
"49	Add Runoff	0.498	0.498	0.566	6.814	"
"50	Channel Design	0.498	0.498	0.566	6.814	"
"51	Channel Route 216	0.498	0.498	0.483	6.814	"
"52	Next link	0.498	0.483	0.483	6.814	"
"53	Catchment 108	0.351	0.483	0.483	6.814	"
"54	Add Runoff	0.351	0.820	0.483	6.814	"
"55	Channel Design	0.351	0.820	0.483	6.814	"
"56	Channel Route 200	0.351	0.820	0.777	6.814	"
"57	Next link	0.351	0.777	0.777	6.814	"
"58	Catchment 109	0.302	0.777	0.777	6.814	"
"59	Add Runoff	0.302	1.017	0.777	6.814	"
"60	Channel Design	0.302	1.017	0.777	6.814	"
"61	Channel Route 170	0.302	1.017	1.012	6.814	"
"62	Combine 1	0.302	1.017	1.012	7.826	"
"63	Start - New Tributary	0.302	0.000	1.012	7.826	"
"64	Catchment 302	0.932	0.000	1.012	7.826	"
"65	Add Runoff	0.932	0.932	1.012	7.826	"
"66	Channel Design	0.932	0.932	1.012	7.826	"
"67	Channel Route 231	0.932	0.932	0.869	7.826	"
"68	Next link	0.932	0.869	0.869	7.826	"
"69	Catchment 304	0.862	0.869	0.869	7.826	"
"70	Add Runoff	0.862	1.707	0.869	7.826	"
"71	Channel Design	0.862	1.707	0.869	7.826	"
"72	Channel Route 164	0.862	1.707	1.593	7.826	"
"73	Next link	0.862	1.593	1.593	7.826	"
"74	Catchment 306	1.111	1.593	1.593	7.826	"

			Qpeaks			
"75	Add Runoff	1.111	2.651	1.593	7.826	"
"76	Channel Design	1.111	2.651	1.593	7.826	"
"77	Channel Route 132	1.111	2.651	2.509	7.826	"
"78	Next link	1.111	2.509	2.509	7.826	"
"79	Catchment 308	0.830	2.509	2.509	7.826	"
"80	Add Runoff	0.830	3.339	2.509	7.826	"
"81	Channel Design	0.830	3.339	2.509	7.826	"
"82	Channel Route 151	0.830	3.339	3.198	7.826	"
"83	Next link	0.830	3.198	3.198	7.826	"
"84	Catchment 309	0.423	3.198	3.198	7.826	"
"85	Add Runoff	0.423	3.528	3.198	7.826	"
"86	Channel Design	0.423	3.528	3.198	7.826	"
"87	Channel Route 107	0.423	3.528	3.504	7.826	"
"88	Next link	0.423	3.504	3.504	7.826	"
"89	Catchment 310	0.648	3.504	3.504	7.826	"
"90	Add Runoff	0.648	3.954	3.504	7.826	"
"91	Channel Design	0.648	3.954	3.504	7.826	"
"92	Channel Route 170	0.648	3.954	3.931	7.826	"
"93	Combine 1	0.648	3.954	3.931	11.757	"
"94	Confluence 1	0.648	11.757	3.931	0.000	"
"95	Pond Route	0.648	11.757	8.168	0.000	"
"96	Next link	0.648	8.168	8.168	0.000	"
"97	Catchment 502	2.062	8.168	8.168	0.000	"
"98	Add Runoff	2.062	8.957	8.168	0.000	"
"99	Channel Design	2.062	8.957	8.168	0.000	"
"100	Channel Route 409	2.062	8.957	8.722	0.000	"

CHANNEL DESIGN   1/1/2002 12:45:05 PM
Manning 'n' changed to 0.040
Basewidth changed to 1.000
Left bank slope changed to 0.000
Right bank slope changed to 0.000
Channel depth changed to 1.000
Depth of flow changed to 0.000
Depth of flow changed to 1.231
Channel depth changed to 1.500
Depth of flow changed to 1.231
CHANNEL Design Accepted

ROUTE   1/1/2002 12:46:56 PM
Reach length changed to 329.850
Peak Outflow changed to 1.011
ROUTE Design Accepted

CHANNEL DESIGN   1/1/2002 12:51:33 PM
Manning 'n' changed to 0.040
Channel depth changed to 2.000
Basewidth changed to 1.500
Depth of flow changed to 1.180
CHANNEL Design Accepted

ROUTE   1/1/2002 12:51:51 PM
Reach length changed to 281.650
Peak Outflow changed to 1.820
ROUTE Design Accepted

CHANNEL DESIGN   1/1/2002 12:58:38 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.757
CHANNEL Design Accepted

ROUTE   1/1/2002 12:58:51 PM
Reach length changed to 598.090
Peak Outflow changed to 2.866
ROUTE Design Accepted

CHANNEL DESIGN   1/1/2002 1:03:07 PM
Manning 'n' changed to 0.040
Basewidth changed to 2.000
Depth of flow changed to 1.543
CHANNEL Design Accepted

ROUTE   1/1/2002 1:03:22 PM
Reach length changed to 243.430
Peak Outflow changed to 3.851
ROUTE Design Accepted

CHANNEL DESIGN   1/1/2002 1:06:53 PM
Manning 'n' changed to 0.040
Basewidth changed to 1.000
Channel depth changed to 1.500
Depth of flow changed to 2.528
Channel depth changed to 1.500
Basewidth changed to 1.500
Depth of flow changed to 1.495
Basewidth changed to 2.000
Depth of flow changed to 1.090
Depth of flow changed to 1.090
CHANNEL Design Accepted

ROUTE   1/1/2002 1:07:36 PM
Reach length changed to 411.300
Peak Outflow changed to 2.368
ROUTE Design Accepted

CHANNEL DESIGN   1/1/2002 1:10:07 PM
Manning 'n' changed to 0.040
Basewidth changed to 1.000
Channel depth changed to 1.000
Depth of flow changed to 0.510
CHANNEL Design Accepted

ROUTE 1/1/2002 1:10:25 PM
Reach length changed to 250.140
Peak Outflow changed to 0.345
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:12:18 PM
Manning 'n' changed to 0.040
Depth of flow changed to 6.171
Channel depth changed to 2.500
Basewidth changed to 2.000
Depth of flow changed to 2.339
CHANNEL Design Accepted

ROUTE 1/1/2002 1:12:45 PM
Reach length changed to 163.310
Peak Outflow changed to 6.311
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:16:11 PM
Manning 'n' changed to 0.040
Channel depth changed to 1.000
Basewidth changed to 1.000
Depth of flow changed to 0.737
CHANNEL Design Accepted

ROUTE 1/1/2002 1:16:28 PM
Reach length changed to 236.530
Peak Outflow changed to 0.566
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:18:15 PM
Manning 'n' changed to 0.040
Channel depth changed to 1.500
Depth of flow changed to 0.653
Channel depth changed to 1.000
Depth of flow changed to 0.653
CHANNEL Design Accepted

ROUTE 1/1/2002 1:18:36 PM
Reach length changed to 215.640
Peak Outflow changed to 0.483
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:19:53 PM
Manning 'n' changed to 0.040
Channel depth changed to 1.500
Depth of flow changed to 0.971
CHANNEL Design Accepted

ROUTE 1/1/2002 1:20:32 PM
Reach length changed to 200.000
Peak Outflow changed to 0.777
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:21:43 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.160
CHANNEL Design Accepted

ROUTE 1/1/2002 1:21:59 PM
Reach length changed to 170.080
Peak Outflow changed to 1.012
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:24:06 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.079
CHANNEL Design Accepted

ROUTE 1/1/2002 1:24:17 PM
Reach length changed to 230.680
Peak Outflow changed to 0.869
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:28:22 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.804
Channel depth changed to 2.000
Depth of flow changed to 1.804
CHANNEL Design Accepted

ROUTE 1/1/2002 1:28:42 PM
Reach length changed to 164.030
Peak Outflow changed to 1.593
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:30:13 PM
Manning 'n' changed to 0.040
Depth of flow changed to 2.670
Channel depth changed to 2.000
Basewidth changed to 2.000
Depth of flow changed to 1.141
CHANNEL Design Accepted

ROUTE 1/1/2002 1:30:34 PM
Reach length changed to 132.400
Peak Outflow changed to 2.509
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:32:31 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.363
CHANNEL Design Accepted

ROUTE 1/1/2002 1:32:43 PM
Reach length changed to 151.430
Peak Outflow changed to 3.198
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:33:40 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.423
CHANNEL Design Accepted

ROUTE 1/1/2002 1:33:50 PM
Reach length changed to 106.660
Peak Outflow changed to 3.504
ROUTE Design Accepted

CHANNEL DESIGN 1/1/2002 1:35:14 PM
Manning 'n' changed to 0.040
Depth of flow changed to 1.557
CHANNEL Design Accepted

ROUTE 1/1/2002 1:35:23 PM
Reach length changed to 169.870
Peak Outflow changed to 3.931
ROUTE Design Accepted

POND DESIGN 1/1/2002 1:36:31 PM
Define Pond Outflow control Weir
Define Pond Weirs
Target outflow changed to 5.878
Target outflow changed to 5.878
Add Weir 1 2.10 0.90 3.40 0.00 0.00
Set Weir 1 2.10 0.90 3.40 0.00 0.00
Pond Outflow computed: Qmax = 4.454
Define Pond Outflow control Orifice
Define Pond Orifices
Target outflow changed to 5.878
Target outflow changed to 5.878
Add Orifice 1 0.00 0.63 0.82
Set Orifice 1 0.00 0.63 0.82 1.00
Pond Outflow computed: Qmax = 6.763
Target outflow changed to 5.878
Levels column in HQV grid re-computed 0.000 to 3.293
Levels column in HQV grid re-computed 0.000 to 3.601

Levels column in HQV grid re-computed 0.000 to 3.924
Peak outflow changed to 11.757
Levels column in HQV grid re-computed 0.000 to 5.000
Define Pond Outflow control Orifice
Define Pond Orifices
Add Orifice 2 0.00 0.63 0.73
Set Orifice 1 0.00 0.63 0.82 1.00
Set Orifice 2 0.00 0.63 0.73 1.00
Pond Outflow computed: Qmax = 31.355
Peak outflow changed to 11.757
Define Pond Outflow control Pipe
Define Pond Pipes
Define Rectangular Pond Layer
Define Rect. Pond Layers
Add Pond Layer 1 2080.00 2.00 0.00 5.00 4.00
Set Pond Layer 1 2080.00 2.00 0.00 5.00 4.00
Pond Volume computed: Vmax = 22741.4
Peak outflow changed to 8.168
Define Rectangular Pond Layer
Define Rect. Pond Layers
Peak outflow changed to 8.168
POND Design Accepted

CHANNEL DESIGN   1/1/2002 1:45:05 PM
Manning 'n' changed to 0.040
Depth of flow changed to 3.059
Channel depth changed to 2.500
Depth of flow changed to 3.059
Channel depth changed to 2.500
Basewidth changed to 2.500
Depth of flow changed to 2.326
CHANNEL Design Accepted

ROUTE   1/1/2002 1:46:02 PM
Reach length changed to 408.630
Peak outflow changed to 8.722
ROUTE Design Accepted

CURRENT RAINFALL INTENSITY = 0.02361 mm/hr

P1 POND INLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)
A1	a10-a14	7.74	0.02	0.32	**0.000**	**0.000**
A2	a14-a15	6.35	0.02	0.48	**0.000**	**0.000**
A3	a15-a16	11.28	0.02	0.43	**0.000**	**0.001**
A4	a16-a17	9.20	0.02	0.52	**0.000**	**0.001**
A5	a24-a20	15.00	0.02	0.52	**0.001**	**0.001**
A7	a38-a29	1.75	0.02	0.50	**0.000**	**0.000**
A10	a29-a21	1.66	0.02	0.36	**0.000**	**0.000**
A6	a30-a32	2.99	0.02	0.36	**0.000**	**0.000**
A8	a32-a33	1.75	0.02	0.45	**0.000**	**0.000**
A9	a33-a34	1.66	0.02	0.40	**0.000**	**0.000**
C2	c2-c3	6.90	0.02	0.48	**0.000**	**0.000**
C4	c3-c4	5.18	0.02	0.52	**0.000**	**0.000**
C6	c4-c5	6.30	0.02	0.54	**0.000**	**0.001**
C8	c5-c6	4.71	0.02	0.54	**0.000**	**0.001**
C9	c6-c7	2.14	0.02	0.56	**0.000**	**0.001**
C10	c7-c8	2.35	0.02	0.58	**0.000**	**0.001**
C11	c14-c18	3.10	0.02	0.54	**0.000**	**0.000**

P2 POND INLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)
B1	b2-b7	6.39	0.0236	0.67	**0.000**	**0.000**
B2	b2-b7	6.39	0.0236	0.66	**0.000**	**0.000**
B3	b12-b26	1.67	0.0236	0.72	**0.000**	**0.000**
B4	b26-b15	3.94	0.0236	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.0236	0.71	**0.000**	**0.000**
B6	b16-b18	5.26	0.0236	0.72	**0.000**	**0.001**

B4	b12-b15	3.94	0.0236	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.0236	0.71	**0.000**	**0.000**
B6	b16-b18	5.26	0.0236	0.67	**0.000**	**0.000**
D1	d1-d3	4.39	0.0236	0.67	**0.000**	**0.000**
D2	d1-d3	4.39	0.0236	0.69	**0.000**	**0.000**
D3	d0-d4	5.10	0.0236	0.68	**0.000**	**0.000**
D4	d0-d14	4.39	0.0236	0.70	**0.000**	**0.000**
D5	d5-d16	6.06	0.0236	0.66	**0.000**	**0.000**
D6	d17-d6	6.06	0.0236	0.67	**0.000**	**0.000**
D7	d7-d18	5.24	0.0236	0.68	**0.000**	**0.000**
D8	d18-d8	5.24	0.0236	0.66	**0.000**	**0.000**
D9	d9-d21	8.30	0.0236	0.63	**0.000**	**0.000**
D10	d9-d21	6.94	0.0236	0.65	**0.000**	**0.000**

P3 POND INLET
RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
C1	c9-c10	7.31	0.02	0.31	**0.000**	**0.000**
C3	c10-c11	6.45	0.02	0.54	**0.000**	**0.000**
C5	c11-c12	6.34	0.02	0.53	**0.000**	**0.001**
C7	c12-c13	7.64	0.02	0.54	**0.000**	**0.001**
E3	e0-e1	3.50	0.02	0.52	**0.000**	**0.000**
E4	e1-c13	4.48	0.02	0.53	**0.000**	**0.000**

P3 POND OUTLET
RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
E2	e2-e5	13.72	0.02	0.49	**0.000**	**0.000**
E1	e6-e7	9.50	0.02	0.52	**0.000**	**0.001**

CURRENT RAINFALL INTENSITY = 0.0333 mm/hr

P1 POND INLET

RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)
A1	a10-a14	7.74	0.03	0.32	**0.000**	**0.000**
A2	a14-a15	6.35	0.03	0.48	**0.000**	**0.001**
A3	a15-a16	11.28	0.03	0.43	**0.000**	**0.001**
A4	a16-a17	9.20	0.03	0.52	**0.000**	**0.001**
A5	a24-a20	15.00	0.03	0.52	**0.001**	**0.001**
A7	a38-a29	1.75	0.03	0.50	**0.000**	**0.000**
A10	a29-a21	1.66	0.03	0.36	**0.000**	**0.000**
A6	a30-a32	2.99	0.03	0.36	**0.000**	**0.000**
A8	a32-a33	1.75	0.03	0.45	**0.000**	**0.000**
A9	a33-a34	1.66	0.03	0.40	**0.000**	**0.000**
C2	c2-c3	6.90	0.03	0.48	**0.000**	**0.000**
C4	c3-c4	5.18	0.03	0.52	**0.000**	**0.001**
C6	c4-c5	6.30	0.03	0.54	**0.000**	**0.001**
C8	c5-c6	4.71	0.03	0.54	**0.000**	**0.001**
C9	c6-c7	2.14	0.03	0.56	**0.000**	**0.001**
C10	c7-c8	2.35	0.03	0.58	**0.000**	**0.001**
C11	c14-c18	3.10	0.03	0.54	**0.000**	**0.000**

P2 POND INLET

RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	Q (m^3/s)	Q link (m^3/s)
B1	b2-b7	6.39	0.03	0.67	**0.000**	**0.000**
B2	b2-b7	6.39	0.03	0.66	**0.000**	**0.000**
B3	b12-b26	1.67	0.03	0.72	**0.000**	**0.000**
B4	b26-b15	3.94	0.03	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.03	0.71	**0.000**	**0.001**
B6	b16-b18	5.26	0.03	0.72	**0.000**	**0.001**

B4	b12-b15	3.94	0.03	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.03	0.71	**0.000**	**0.000**
B6	b16-b18	5.26	0.03	0.67	**0.000**	**0.000**
D1	d1-d3	4.39	0.03	0.67	**0.000**	**0.000**
D2	d1-d3	4.39	0.03	0.69	**0.000**	**0.000**
D3	d0-d4	5.10	0.03	0.68	**0.000**	**0.000**
D4	d0-d14	4.39	0.03	0.70	**0.000**	**0.000**
D5	d5-d16	6.06	0.03	0.66	**0.000**	**0.000**
D6	d17-d6	6.06	0.03	0.67	**0.000**	**0.000**
D7	d7-d18	5.24	0.03	0.68	**0.000**	**0.000**
D8	d18-d8	5.24	0.03	0.66	**0.000**	**0.000**
D9	d9-d21	8.30	0.03	0.63	**0.000**	**0.000**
D10	d9-d21	6.94	0.03	0.65	**0.000**	**0.000**

P3 POND INLET
RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
C1	c9-c10	7.31	0.03	0.31	**0.000**	**0.000**
C3	c10-c11	6.45	0.03	0.54	**0.000**	**0.001**
C5	c11-c12	6.34	0.03	0.53	**0.000**	**0.001**
C7	c12-c13	7.64	0.03	0.54	**0.000**	**0.001**
E3	e0-e1	3.50	0.03	0.52	**0.000**	**0.000**
E4	e1-c13	4.48	0.03	0.53	**0.000**	**0.000**

P3 POND OUTLET
RETURN PERIOD 50 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
E2	e2-e5	13.72	0.03	0.49	**0.001**	**0.001**
E1	e6-e7	9.50	0.03	0.52	**0.000**	**0.001**

CURRENT RAINFALL INTENSITY = 0.0375 mm/hr

P1 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
A1	a10-a14	7.74	0.04	0.32	**0.000**	**0.000**
A2	a14-a15	6.35	0.04	0.48	**0.000**	**0.001**
A3	a15-a16	11.28	0.04	0.43	**0.001**	**0.001**
A4	a16-a17	9.20	0.04	0.52	**0.000**	**0.002**
A5	a24-a20	15.00	0.04	0.52	**0.001**	**0.001**
A7	a38-a29	1.75	0.04	0.50	**0.000**	**0.000**
A10	a29-a21	1.66	0.04	0.36	**0.000**	**0.000**
A6	a30-a32	2.99	0.04	0.36	**0.000**	**0.000**
A8	a32-a33	1.75	0.04	0.45	**0.000**	**0.000**
A9	a33-a34	1.66	0.04	0.40	**0.000**	**0.000**
C2	c2-c3	6.90	0.04	0.48	**0.000**	**0.000**
C4	c3-c4	5.18	0.04	0.52	**0.000**	**0.001**
C6	c4-c5	6.30	0.04	0.54	**0.000**	**0.001**
C8	c5-c6	4.71	0.04	0.54	**0.000**	**0.001**
C9	c6-c7	2.14	0.04	0.56	**0.000**	**0.001**
C10	c7-c8	2.35	0.04	0.58	**0.000**	**0.002**
C11	c14-c18	3.10	0.04	0.54	**0.000**	**0.000**

P2 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
B1	b2-b7	6.39	0.04	0.67	**0.000**	**0.000**
B2	b2-b7	6.39	0.04	0.66	**0.000**	**0.000**
B3	b12-b26	1.67	0.04	0.72	**0.000**	**0.000**
B4	b26-b15	3.94	0.04	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.04	0.71	**0.000**	**0.001**
B6	b16-b18	5.26	0.04	0.72	**0.000**	**0.001**

B4	b12-b15	3.94	0.04	0.71	**0.000**	**0.000**
B5	b22-b16	2.94	0.04	0.71	**0.000**	**0.000**
B6	b16-b18	5.26	0.04	0.67	**0.000**	**0.000**
D1	d1-d3	4.39	0.04	0.67	**0.000**	**0.000**
D2	d1-d3	4.39	0.04	0.69	**0.000**	**0.000**
D3	d0-d4	5.10	0.04	0.68	**0.000**	**0.000**
D4	d0-d14	4.39	0.04	0.70	**0.000**	**0.000**
D5	d5-d16	6.06	0.04	0.66	**0.000**	**0.000**
D6	d17-d6	6.06	0.04	0.67	**0.000**	**0.000**
D7	d7-d18	5.24	0.04	0.68	**0.000**	**0.000**
D8	d18-d8	5.24	0.04	0.66	**0.000**	**0.000**
D9	d9-d21	8.30	0.04	0.63	**0.001**	**0.001**
D10	d9-d21	6.94	0.04	0.65	**0.000**	**0.000**

P3 POND INLET

RETURN PERIOD 100 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
C1	c9-c10	7.31	0.04	0.31	**0.000**	**0.000**
C3	c10-c11	6.45	0.04	0.54	**0.000**	**0.001**
C5	c11-c12	6.34	0.04	0.53	**0.000**	**0.001**
C7	c12-c13	7.64	0.04	0.54	**0.000**	**0.001**
E3	e0-e1	3.50	0.04	0.52	**0.000**	**0.000**
E4	e1-c13	4.48	0.04	0.53	**0.000**	**0.000**

P3 POND OUTLET

RETURN PERIOD 10 ARI

Area	Nodes	Catch. Area (ha)	$^{10}I_{tc}$	C	**Q (m^3/s)**	**Q link (m^3/s)**
E2	e2-e5	13.72	0.04	0.49	**0.001**	**0.001**
E1	e6-e7	9.50	0.04	0.52	**0.001**	**0.001**

APPENDIX D

POND CALCULATION

STEP 1 : DETERMINE STORAGE VOLUME REQUIRED

1 Determine the amount of impervious and pervious areas draining to the OSD storage system

Impervious area = 2010245 m^2
Pervious area = 1340163 m^2

The site conditon before development was bare earth = 3350407.6 m^2

2 Determine times of concentration, tc and tcs

Peak flow time of concentration from the top of the catchment to a designated outlet or point of concern tc = 60 minutes

Peak flow time of concentration from the top of the catchment to the development site
tcs = 35 minutes

3 Calculate the pre and post-development flows for the area draining to the OSD storage

The rainfall intensity is estimated using Equation 13.2 and Table 13.A1 (Kuala Lumpur) using 10 year ARI capacity :

a = 5.3431
b = 0.3538
c = -0.1686
d = 0.0078

$\ln {}^{y}I_t = a + b(\ln t_c) + c(\ln t_c)^2 + d(\ln t_c)^3$
Rainfall intensity, ${}^{50}I_{30}$ = 90.079 mm/hr

Using the Rational Method, the pre and post-development flows are calculated as follows :

Development Status	I (mm/hr)	Impervious Area		Pervious Area		Total CA	Q (l/s)	
		C	A (m^2)	C	A (m^2)			
Pre-development	90.079	-	-	0.7	3350407.6	2345285.32	Qp	58683.70
Post-development	90.079	0.85	2010244.56	0.6	1340163.04	2512805.7	Qa	62875.39

4 Determine the required PSD.

To calculate the Permissible Site Discharge (PSD)
PSD = $\{a - (a2 - 4b)^{1/2}\} / 2$ (Equation 19.1)

For above-ground storage :
a = $\{4 (Qa / tc)\} \{0.333\ tc (Qp / Qa) + 0.75\ tc + 0.25\ tcs \}$ (Equation 19.1a)
b = 4 Qa Qp (Equation 19.1b)

where :
Qp = the peak pre-development flow from the site for the discharge design storm with a duration equal to tc (l/s)

Qa = the peak post-development flow from the site for the discharge design storm with a duration equal to tc (l/s)

The peak pre-development flow, Qp = 58683.70 l/s
The peak post-development flow, Qa = 62875.39 l/s

a = 303470.17
b = 1.4759E+10

Permissible Site Discharge, PSD = 60825.82 l/s

5 Determine the required SSR

To calculate the Site Storage Requirement (SSR)

SSR = 0.06 td (Qd - c - d) (Equation 19.2)

For above-ground storage :

c = 0.875 PSD { 1 - 0.459 (PSD / Qd) } (Equation 19.2a)

d = 0.214 (PSD^2 / Qd) (Equation 19.2b)

where :

td = selected storm duration (minutes)

Qd = the peak post-development flow from the site for a storm duration equal to td (l/s)

The site discharge for the 10 year ARI and the corresponding SSR is calculated for a range of storm durations to determine the maximum SSR. These calculations are summarised in the following two tables.

td (min)	I (mm/hr)	Impervious Area		Pervious Area		Total CA	Qd (l/s)
		C	A (m^2)	C	A (m^2)		
5	315.33	0.91	2010245	0.74	1340163	2821043.2	247097.73
10	247.43	0.91	2010245	0.74	1340163	2821043.2	193890.20
15	200.86	0.9	2010245	0.74	1340163	2800940.75	156275.08
20	169.16	0.9	2010245	0.73	1340163	2787539.12	130981.11
30	130.35	0.9	2010245	0.72	1340163	2774137.49	100447.07
50	78.21	0.9	2010245	0.71	1340163	2760735.86	59977.09

td (mins)	Qd (l/s)	PSD (l/s)	c	d	SSR (m^3)
5	247097.73	60825.82	47209.08	3204.21	59005.3319
10	193890.20	60825.82	45558.85	4083.51	86548.7042
15	156275.08	60825.82	43714.20	5066.41	96745.0231
20	130981.11	60825.82	41878.02	6044.79	**99669.9608**
30	100447.07	60825.82	38429.49	7882.29	97443.5249
50	59977.09	60825.82	28447.73	13200.92	54985.313

From the previous table, a maximum SSR **97444** m^3 occurs at a duration of 30 minutes.
However an additional 10% is added to the volume to account for inaccuracies in construction.
Therefore :

Required SSR = 1.1 x 97444 = **107188** m^3

STEP 2 : SIZE PRIMARY OUTLET

The primary outlet orifice is sized to discharge the PSD assuming free outlet conditions when the storage is full. Using 0.5 m deep Discharge Control Pit,DCP and a maximum storage depth of 1.5 m, adopt a maximum head to the centreline of 1.9 m. The required orifice size under free outlet conditons is calculated by Equation 19.3:

$$PSD = Cd\ Ao\ (2g\ Ho)^{1/2}$$

$$Ao = \frac{2710 \times 10^{-3}}{0.62 \times (2 \times 9.81 \times 1.50)^{1/2}} = 18.084 \text{ m}^2$$

$$Do = (4\ Ao / 3.142)^{1/2} = 4.798 \text{ m diameter}$$

Outlet Size* = *900* *mm* *diameter

STEP 3 : DETERMINE STORAGE DIMENSIONS

The minimum recommended floor slope is 2% graded toward the DCP. Assuming the average depth in the storage is 1.5 m, the adopted dimensions of the storage volume are :

Required SSR = **107188** m^3

Rectangle shape required for OSD :

Depth = 5 m

Width = 100 m

Length = 500 m

Volume = 250000 m (OK)

Storage Dimension = 500 m (Length) x 100 m (Width) x 15 m (Depth)

STEP 4 : SIZE SECONDARY OUTLET

The secondary outlet is a broad-crested weir along the boundary.
The tcs=35 minute and 50 year ARI rainfall intensity for Malacca is estimated using Equation 13.3

${}^{50}I_{35}$ = 104.19 mm/hr

Using the Rational Method, the major system flow is calculated as follows :

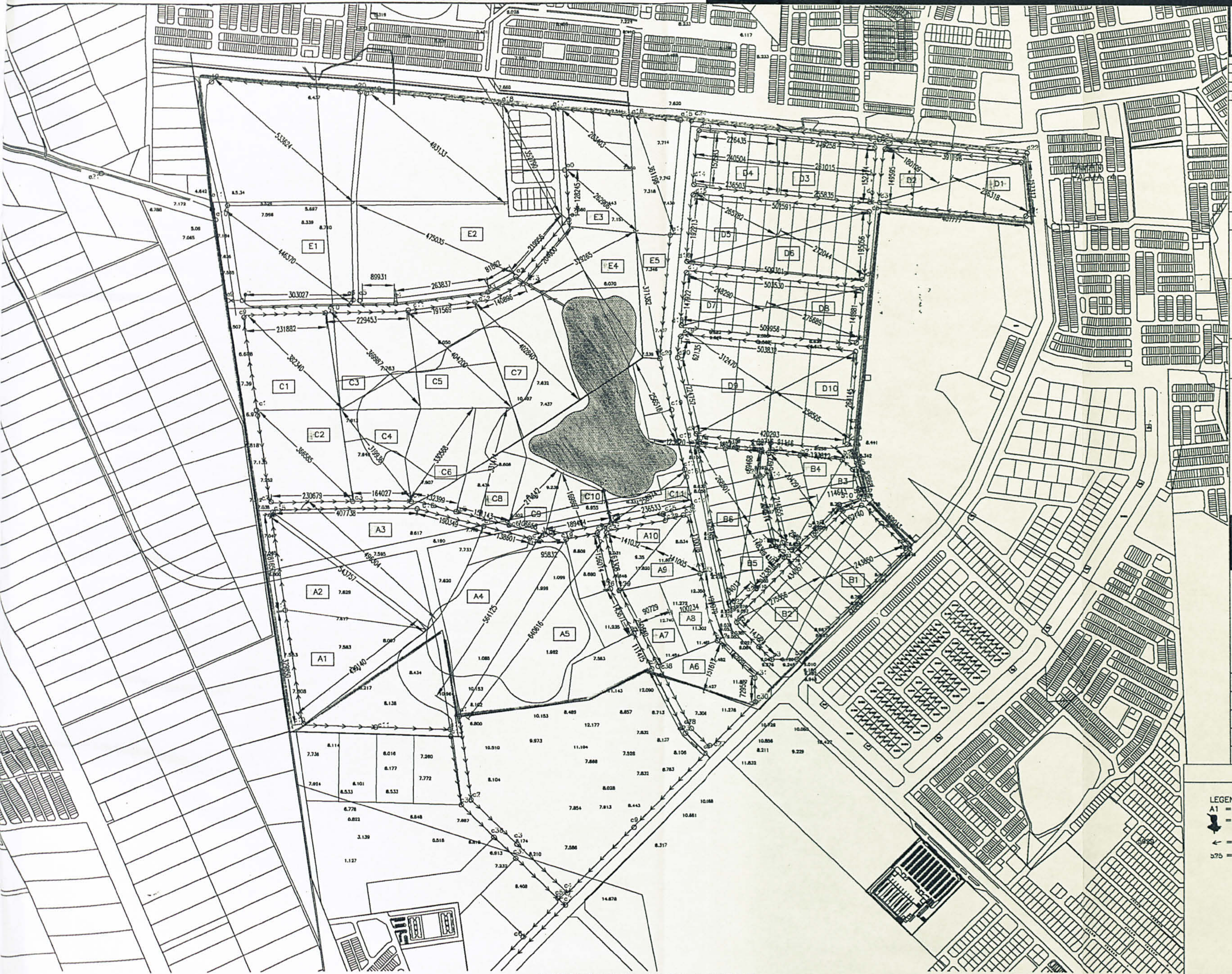
I (mm/hr)	Impervious Area		Pervious Area		Total CA	Q (l/s)
	C	A (m^2)	C	A (m^2)		
104.195	0.85	2010244.6	0.65	1340163.04	2579814	74667.68

Assuming the head over the weir is limited to 600 mm and C_{BCW} = 1.70,
rearranging Equation 20.5 gives :

$$B = \frac{Qd}{C_{BCW}\, H^{1.5}} = \frac{74.66768}{1.44 \times 0.45^{1.5}} = 172 \text{ m}$$

Allowing 50 mm freeboard, the dimensions of the secondary outlet weir are :
6.0 m (wide) x 0.5 m (height)

APPENDIX E



CATCHMENT AREA LAYOUT
SCALE 1 : 5000

THE CONTRACTOR IS TO CHECK AND VERIFY ALL DIMENSION PRIOR TO PROCEEDING WORK. FIGURE DIMENSION(S) TO BE READ IN PREFERENCE OF SCALE MEASUREMENT. ANY DISCREPANCIES FOUND SHALL REPORT TO THE ARCHITECT IMMEDIATELY

NO	DATE	AMENDMENT	BY

PROJECT TITLE :

PROPOSED OF UTILISATION OF UTILIZATION OF ABONDONED MINING POND AS RETENTION POND TO CATER STORMWATER MANAGEMENT
AT LOT
KAMUNTING RAYA, TAIPING
PERAK DARUL RIDZUAN
FOR FINAL YEAR PROJECT 2

DRAWING TITLE : -

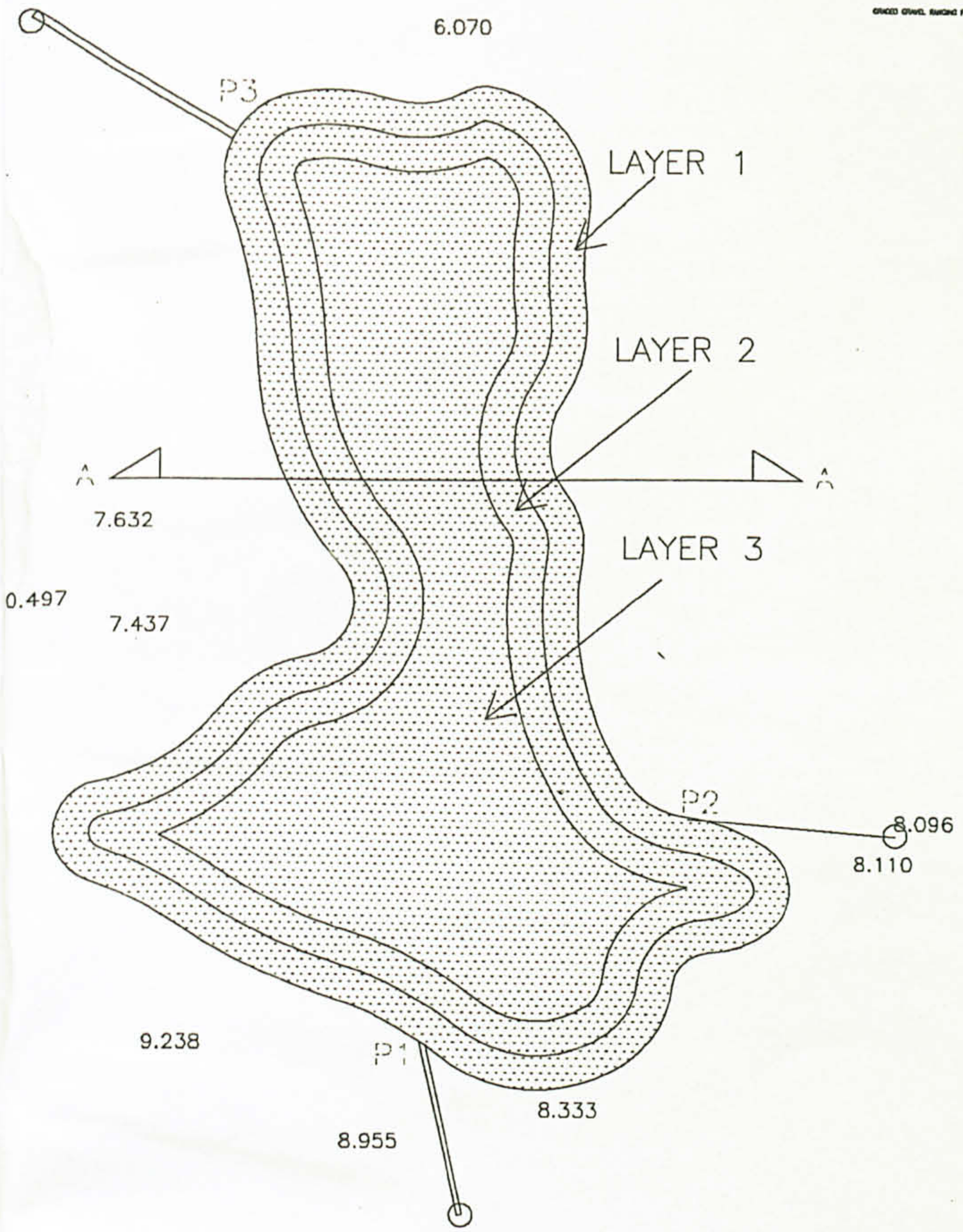
OWNER'S SIGNATURE :

ENGINEER'S SIGNATURE :

DESIGN BY: AINIL	DRAWN BY: AINIL
CHECKED BY: AINIL	APPROVED BY: AINIL
DATE: JAN 2010	SCALE: 1:5000
PROJECT REF.: FYP2/01	
DRAWING NO: 01	

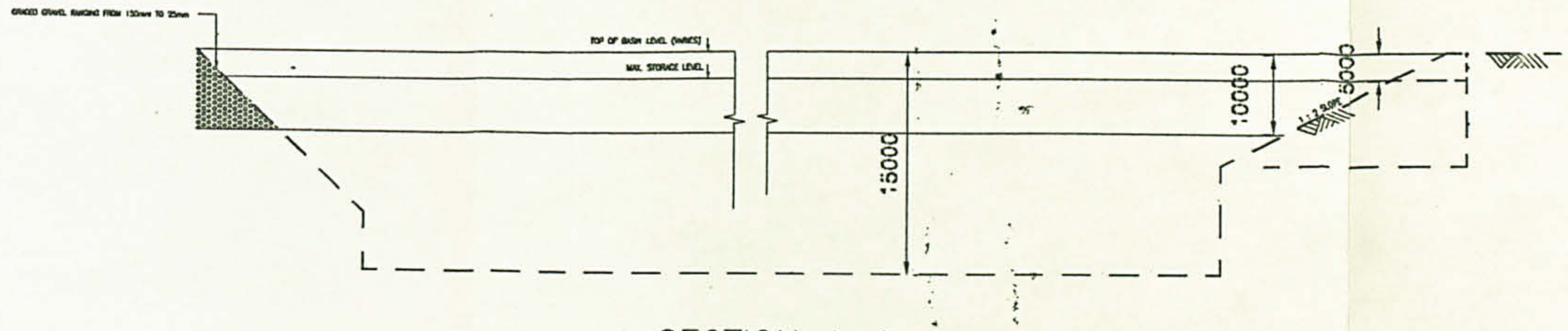
LEGEND
A1 = The Catchment Label
= Retention Pond
← = Flow of Water
525 = Node

APPENDIX F



RETENTION POND DETAIL

SCALE 1 : 2000 AREA : 11.84 Hc



SECTION A-A

N.T.S

LEGEND

= Retention Pond

P1,P2,P3 = Flow of Water

8.333 = Ground Level

LAYER 1

AREA=31200m2
DEPTH=5m
VOLUME=156000m3

LAYER 2

AREA=28800m2
DEPTH=10m
VOLUME=280000m3

LAYER 3

AREA=56800m2
DEPTH=15m
VOLUME=852000m3

NO	DATE	AMENDMENT	BY

PROJECT TITLE :

PROPOSED OF UTILISATION OF UTILIZATION OF ABONDONED MINING POND AS RETENTION POND TO CATER STORMWATER MANAGEMENT AT LOT KAMUNTING RAYA, TAIPING PERAK DARUL RIDZUAN FOR FINAL YEAR PROJECT 2

DRAWING TITLE :

RETENTION POND LAYOUT AND DETAILS

OWNER'S SIGNATURE :

ENGINEER'S SIGNATURE :

DESIGN BY:	AINIL	DRAWN BY:	AINIL
CHECKED BY:	AINIL	APPROVED BY:	
DATE:	JAN 2010	SCALE:	1:2000
PROJECT REF.:	FYP2/01		
DRAWING NO:	02		